SECTION 22 33 00

ELECTRIC, DOMESTIC -WATER HEATER

PART 1 - GENERAL

1.1 SUMMARY

A. Commercial, electric, storage, domestic-water heaters.

B. Thermostat-control, electric, tankless, domestic-water heaters.

C. Domestic-water heater accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated.

B. Shop Drawings:

1. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

B. Source quality-control reports.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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.

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex, "Drinking Water System Components - Health Effects."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.

a. Commercial, Electric, Storage, Domestic-Water Heaters:

1) Storage Tank: Five years.
2) Controls and Other Components: Five years.

b. Electric, Tankless, Domestic-Water Heaters: Five year(s).
c. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Storage, Domestic-Water Heaters:

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

a. Lochinvar.
b. A. O. Smith
c. Bradford White
d. Or approved equal.

2. Standard: UL 1453.
3. Storage-Tank Construction: ASME-code, steel vertical arrangement.

a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.

b. Pressure Rating: 150 psig (1035 kPa).
c. Interior Finish: Comply with NSF 61 Annex barrier materials for potable-water tank linings, including extending lining material into tappings.

4. Factory-Installed Storage-Tank Appurtenances:

    a. Anode Rod: Replaceable magnesium.
    b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
    c. Insulation: Comply with ASHRAE/IESNA 90.1.
    d. Jacket: Steel with enameled finish.
    e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
    f. Temperature Control: Adjustable thermostat.
    g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
    h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

B. Capacity and Characteristics:

1. Capacity: Refer to schedules on drawings.
2. Recovery: Refer to schedules on drawings.
3. Temperature Setting: 140 deg F (60 deg C).
4. Power Demand: Refer to schedules on drawings.
5. Heating Elements: Refer to schedules on drawings.
6. Electrical Characteristics:

    a. Volts: Refer to schedules on drawings..
    b. Phases: Refer to schedules on drawings.
    c. Hertz: 60.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

1. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

2. Construction:

    a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
    b. Interior Finish: Comply with NSF 61 Annex barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
    c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics:

    a. Working-Pressure Rating: 150 psig (1035 kPa).
    b. Capacity Acceptable: Refer to schedules on drawings.
    c. Air Precharge Pressure: Per manufacturer’s recommendation.

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

D. Heat-Trap Fittings: ASHRAE 90.2.

E. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig- (172.5-kPa-) maximum outlet pressure unless otherwise indicated.

F. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

G. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.

H. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

I. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

J. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of 18 inches (457 mm) above the floor.

K. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base.

1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters at least 18 inches (457 mm) above floor on wall bracket.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
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.
5. Anchor domestic-water heaters to substrate.

C. Install electric, domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install combination temperature-and-pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

G. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

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

I. Fill electric, domestic-water heaters with water.

J. Charge domestic-water compression tanks with air.

2.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

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

2.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

2.4 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.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. This Section is intended to replace the following AIA Sections:

1. Section 22 42 13.13 "Commercial Water Closets."
2. Section 22 42 13.16 "Commercial Urinals."
3. Section 22 42 16.13 "Commercial Lavatories."
4. Section 22 42 16.16 "Commercial Sinks."
5. Section 22 42 33 "Wash Fountains."
6. Section 22 45 00 "Emergency Plumbing Fixtures."
7. Section 22 47 13 "Drinking Fountains."
8. Section 22 47 16 "Pressure Water Coolers."
9. Section 22 47 23 "Remote Water Coolers."

1.2 SUMMARY

A. Section Includes:

1. Water Closets
2. Urinals
3. Lavatories
4. Sinks
5. Service Sinks
6. Wash Fountains
7. Showers, Receptors and Basins
8. Emergency Plumbing Fixtures
9. Drinking Fountains
10. Water Coolers

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

3. Documentation indicating flow and water consumption requirements.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS

A. Water Closets: Floor mounted, bottom outlet, top spud.

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

a. American Standard
b. Kohler Commercial
c. Zurn Industries
d. Crane
e. Toto
f. Sloan
g. Or Approved Equal

2. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet.
d. Style: Flushometer valve.
e. Height: Standard AND Handicapped, complying with ICC/ANSI A117.1.
f. Rim Contour: Elongated.
g. Water Consumption: 1.28 gal. (4.8 L) per flush.
h. Spud Size and Location: NPS 1-1/2 (DN 40); top.
i. Color: White.

3. Bowl-to-Drain Connecting Fitting: ASTM A1045 or ASME A112.4.3.
4. Flushometer Valve: Refer to Drawings
5. Toilet Seat: Open-front, elongated, antimicrobial
6. Support: Not required

2.2 WATER CLOSET FLUSHOMETER VALVES

A. Lever-Handle, Piston Flushometer Valves:

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

a. Sloan
b. Zurn Industries
c. Delaney
d. Optima
e. Chicago Faucet
f. Or Approved Equal

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: **Exposed**.
9. Consumption: 1.28 gal. (4.8 L) per flush.
10. Minimum Inlet: NPS 1 (DN 25).
11. Minimum Outlet: NPS 1-1/4 (DN 32).

2.3 TOILET SEATS

A. Toilet Seats:

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

a. Centoco
b. Church
c. Zurn
d. Bemis
e. Toto
f. Or Approved Equal

2. Standard: IAPMO/ANSI Z124.5.
3. Material: Antimicrobial plastic.
4. Type: Commercial (Heavy duty).
5. Shape: Elongated rim, open front.
6. Hinge: Self-sustaining, check.
7. Hinge Material: Non-corroding metal.
8. Color: White.

2.4 WALL-HUNG URINALS

A. Urinals: Wall hung, back outlet, siphon jet, accessible.

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

a. American Standard
b. Kohler Commercial
c. Zurn Industries
d. Crane
e. Toto
f. Or Approved Equal

2. Fixture:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet with extended shields.
d. Strainer or Trapway: Integral trap.
e. Water Consumption: 0.125 gal. (0.47 L)
f. Spud Size and Location: NPS 3/4 (DN 20); top.
g. Outlet Size and Location: NPS 2 (DN 50); back.
h. Color: White.

3. Waste Fitting:

a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
b. Size: NPS 2 (DN 50).

4. Support: ASME A112.6.1M, Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.

2.5 URINAL FLUSHOMETER VALVES

A. Lever-Handle, Piston Flushometer Valves:

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

a. Sloan
b. Zurn
c. Delaney
d. Crane
e. Toto
f. Or Approved Equal

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed or Concealed.

9. Consumption: 0.125 gal. (0.47 L) per flush.

2.6 LAVATORIES

A. Lavatories: Rectangular enameled cast iron, wall mounted.

1. Enameled Cast-Iron Lavatories:

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

1) American Standard
2) Kohler Commercial
3) Zurn
4) Crane
5) Toto
6) Sloan
7) Or Approved Equal

2. Fixtures:

a. Standard: ASME A112.19.2/CSA B45.1 for vitreous-china lavatories.
b. Type: Flat rim with ledge.
c. Rectangular Nominal Size: 19 by 16 inches (483 by 406 mm)
d. Faucet-Hole Punching: Three holes, 2-inch (51-mm) centers or Three holes, 4-inch (102-mm) centers.
e. Color:White.

3. Faucet: Refer to Drawings
4. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
5. Waste Fittings: Comply with requirements in "Waste Fittings" Article.
6. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

2.7 LAVATORY FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Lavatory Faucets: Two-handle mixing valve.

1. General-Duty, Solid-Brass Faucets:

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

1) American Standard
2) Kohler
3) T&S Brass
4) Chicago Faucet
5) Crane
6) Toto
7) Sloan
8) Delta
9) Moen
10) Fister
11) Or Approved Equal

2. General-Duty, Copper- or Brass-Underbody Faucets:

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

      1) American Standard
      2) Kohler
      3) Chicago Brass
      4) T&S Brass Co
      5) Crane
      6) Toto
      7) Sloan
      8) Delta
      9) Moen
      10) Fister
      11) Or Approved Equal

3. Standard: ASME A112.18.1/CSA B125.1.
4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
5. Body Material: General-duty, solid brass.
6. Finish: Polished chrome plate.
7. Maximum Flow Rate: 0.5 gpm (1.9L/min).
8. Centers: 4 inches (102 mm) or Adjustable.
9. Mounting: Deck, exposed.
10. Valve Handle(s): Wrist blade, 4 inches (102 mm).
11. Inlet(s): NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor.
12. Spout: Rigid.
13. Spout Outlet: Aerator.
14. Operation: Compression, manual.
15. Drain: Grid.

2.8 SINK FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Sink Faucets:

1. General-Duty, Solid-Brass Faucets:

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

1) American Standard
2) Kohler
3) T&S Brass
4) Chicago Faucet
5) Crane
6) Toto
7) Sloan
8) Delta
9) Moen
10) Or Approved Equal

2.9 SERVICE BASINS

A. Service Basins: Terrazzo, Floor Mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Acorn Engineering Company; a Division of Morris Group International.
   b. Florestone Products Co., Inc.
   c. Stern Williams Co., Inc.
   d. Fiat
   e. Or approved equal

2. Fixture:
   a. Standard: IAPMO PS 99.
   b. Shape: Refer drawing
   c. Nominal Size: Refer drawing.
   d. Height: Refer drawing.
   e. Rim Guard: On all top surfaces.
   f. Color: Refer drawing.
   g. Drain: Grid with NPS 3 outlet.

3. Mounting: On floor and flush to wall.

2.10 UTILITY SINKS

A. Utility Sinks: Stainless steel, counter mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard
   b. Elkay
   c. Or approved equal

2. Fixture:
   a. Standard: ASME A 112.19.3/CSA B45.4.
   b. Type: Ledge back.
   c. Number of Compartments: One.
      1) Drain: Grid with NPS 1-1/2 tailpiece and twist drain.
      2) Drain Location: Centered in compartment.

3. Supply Fittings:
   a. Standard: ASME A112.18.1/CSA B125.1.
   b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
      1) Operation: Loose Key.
      2) Risers: NPS ½, ASME A112.18.6, braided or corrugate stainless steel flexible hose.

4. Waste Fittings:
   a. Standard: ASME A112.18.2/CSA B125.2.
   b. Trap(s):
      1) Size: NPS 1-1/2.
      2) Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inchthick brass tube to wall; and chrome-plated brass or steel wall flange.
      3) Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless-steel tube to wall; and stainless-steel wall flange.

   c. Continuous Waste:
      1) Size: NPS 1-1/2.
      2) Material: Chrome-plated, 0.032-inch-thick brass tube.

5. Mounting: On counter with sealant.

6. Faucet: Refer to plumbing schedule.

2.11 SERVICE SINKS

A. Service Sinks: Enameled, cast iron, trap standard mounted.

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

    a. Fiat
    b. Florstone
    c. American Standard
    d. Kohler
    e. Acorn
    f. Mustee
    g. Stern and Williams
    h. Or approved equal

2. Standard: ASME A112.19.1/CSA B45.2.
3. Type: Service sink with back.
4. Back: Plain.
5. Nominal Size: 22 by 18 inches (560 by 457 mm).
6. Color: White.
7. Mounting: NPS 2 (DN 50) P-trap standard with grid strainer inlet, cleanout, and floor flange.
8. Rim Guard: On front and sides.
9. Faucet: Refer to Plumbing Schedule.
10. Support: Bottom of trap.

2.12 COMBINATION EMERGENCY SHOWER WITH EYE/FACE WASH UNITS

A. Accessible, Plumbed Emergency Shower with Eye/Face Wash Combination Units:

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

    a. Guardian
    b. Bradley
    c. Speakman
    d. Haws
    e. Or Approved Equal

2. Piping:

    a. Material: Chrome-plated brass or stainless steel.
    b. Unit Supply: NPS 1-1/4 (DN 32) minimum.
    c. Unit Drain: Outlet at back or side near bottom.

3. Shower:

    a. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
    b. Supply Piping: NPS 1 (DN 25) with flow regulator and stay-open control valve.
    c. Control-Valve Actuator: Pull rod.

d. Shower Head: 8-inch-(200-mm-) minimum diameter, chrome-plated brass or stainless steel.
e. Mounting: Pedestal.

4. Eye/Face Wash Unit:

a. Capacity: Not less than 3 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
e. Receptor: Chrome-plated brass or stainless-steel bowl.
f. Mounting: Attached to shower pedestal.
g. Drench-Hose Option: May be provided instead of eye/face wash unit.

1) Capacity: Not less than 3 gpm (11.4 L/min.) for at least 15 minutes.
2) Drench Hose: Hand-held spray head with squeeze-handle actuator and hose.
3) Mounting: Bracket on shower pedestal.

2.13 WATER-TEMPERING EQUIPMENT FOR EMERGENCY FIXTURES

A. Hot- and Cold-Water, Water-Tempering Equipment:

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

a. Guardian
b. Bradley
c. Speakman
d. Haws
e. Or Approved Equal

2. Description: Factory-fabricated equipment with thermostatic mixing valve.

a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
b. Supply Connections: For hot and cold water.

2.14 WATER COOLERS

A. Pressure Water Coolers: Wall mounted with bottle fill, wheelchair accessible.

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

a. Elkay
b. Haws
c. Halsey Taylor
d. Or Approved Equal

2. Cabinet: Bi-level with two attached cabinets, all stainless steel.
3. Control: Push bar.
4. Supply: NPS 3/8 (DN 10) with shutoff valve.
5. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
6. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
7. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

    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.

8. Capacities and Characteristics:

    a. Refer to Drawings.

9. Support: ASME A112.6.1M, Type I water-cooler carrier.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing-fixture installation.

B. Examine walls, floors, cabinets, and counters for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Install plumbing fixtures level and plumb according to roughing-in drawings.

B. Install floor-mounted water closets on closet flange attachments to drainage piping.

C. Install counter-mounting fixtures in and attached to casework.

D. Install pedestal lavatories on pedestals and secured to wood blocking in wall.

E. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Comply with valve requirements specified in Section 200523 "General-Duty Valves for Mechanical, Plumbing and Fire Suppression."

F. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

G. Install toilet seats on water closets.

H. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

I. Install shower flow-control fittings with specified maximum flow rates in shower arms.

J. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes unless otherwise indicated.

K. Install disposer in outlet of each sink indicated to have a disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

L. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sinks, as required. Comply with requirements in Section 20 70 0 "Thermal Insulation for Mechanical, Plumbing and Fire Suppression."

M. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 20 05 17 "Sleeves, Seals and Escutcheons for Mechanical, Plumbing and Fire Suppression."

N. Seal joints between plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 20 11 01 "Above-ground Piping for Mechanical, Plumbing and Fire Suppression."

C. Comply with soil and waste piping requirements specified in Section 20 11 01 "Above-ground Piping for Mechanical, Plumbing and Fire Suppression."

3.4 ADJUSTING

A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of plumbing fixtures, inspect and repair damaged finishes.

B. Clean plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed plumbing fixtures and fittings.

D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

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SECTION 22 42 23

COMMERCIAL SHOWERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Individual shower stalls.
2. Shower faucets.
3. Accessories
4. Grout.

1.03 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 showers and basins.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For shower faucets to include in maintenance manuals.

B. Maintenance Data and cleaning instructions for shower surfaces.

PART 2 - PRODUCTS

2.01 INDIVIDUAL SHOWER STALLS

A. Accessible Shower Stalls:

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. Clarion Bathware.
   b. Florestone Products Co., Inc.
   c. Best Bath Systems
   d. Or Approved Equal

2. General: Gel coated FRP shower enclosure and accessories compliant with requirements of the North Carolina Building Code, chapter 11.

3. Standard: ANSI Z124.1.2.

4. Type: One-piece unit without top, integral basin.

5. Style: Wheelchair accessible, commercial.

6. Nominal Size and Shape: 63 by 36 inches rectangular, 78 inches high

7. Color: White.

8. Bathing Surface: Slip resistant according to ASTM F 462.

9. Outlet: Removable chrome plated grid strainer, tailpiece, NPS 2.

10. Accessories (Factory Installed):
    a. Grab Bars: ASTM F 446. Comply with ADAAG 2010 Standard.
    b. NOT USED
    c. Integral Soap Dish, recessed mount.

11. Accessories (Furnished with Shower; Installed by Contractor):
    a. Shower Curtain Rod: 1 inch diameter, 304 stainless steel.
    b. Curtain: Vinyl, mold resistant, full height and width of shower stall entrance.
    c. Collapsible 3/4 inch threshold.

2.02 SHOWER FAUCETS

A. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for shower materials that will be in contact with potable water.

B. Shower Faucets:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
    a. Chicago Faucets.
    b. Leonard Valve Company.
    c. Or approved equal.

2. Description: Single-handle, pressure-balance mixing valve with hot- and cold-water indicators; check stops; and shower head.

3. Faucet:
    a. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016.
    b. Body Material: Solid brass.
    c. Finish: Polished chrome plate.
    d. Maximum Flow Rate: 2.5 gpm.
    e. Mounting: Exposed.
    f. Operation: Metal lever, single-handle, twist or rotate control. Pressure balancing ceramic disc valve cartridge to maintain constant temperature in response to changes in relative hot and cold water supply pressure.
    g. Anti-scald Device: Adjustable hot limit safety stop; integral with mixing valve.

h. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

4. Supply Connections: NPS 1/2.

5. Shower Head:
   a. Standard: ASME A112.18.1/CSA B125.1.
   b. Type: Hand shower and a 36 inch slide bar with adjustable shower holder.
   c. Shower Head Material: Metallic with chrome-plated finish.
   d. Spray Pattern: Fixed.

2.03 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

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

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before shower installation.

B. Examine walls and floors for suitable conditions where showers will be installed.

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

3.02 INSTALLATION

A. Coordinate shower stall rough-in (walls and threshold) with General Contractor.

B. Assemble shower components and accessories according to manufacturers' written instructions.

C. Field install drains and shower faucets in accordance with North Carolina Building Code, Chapter 11 requirements, and the North Carolina Plumbing Code.

D. Install showers level and plumb according to roughing-in drawings.

E. Install water-supply piping with shutoff ball valve on each supply to each shower faucet. Install valves where they can be easily reached for operation.

F. Install shower flow-control fittings with specified maximum flow rates in shower head.

G. Set shower stalls in leveling bed of cement grout. Threshold height shall meet North Carolina Building Code requirements. Coordinate recessed slab, if necessary to comply with threshold height requirements, with General Contractor.

H. Seal joints between showers and floors and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.03 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

3.04 ADJUSTING

A. Operate and adjust showers and controls. Replace damaged and malfunctioning showers, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.05 CLEANING AND PROTECTION

A. After completing installation of showers, inspect and repair damaged finishes.

B. Clean showers, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed fixtures and fittings.

D. Do not allow use of showers and basins for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 23 01 00

COMMON WORK REQUIREMENTS FOR MECHANICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Basic requirements applicable to all Division 23 work.

1.2 RELATED SECTIONS

A. All specification sections in Division 20 are applicable to Division 23. It is the responsibility of the Division 23 Contractor to obtain all Division 20 specifications and conform to all applicable requirements. Division 20 Sections included are:

1. [**Section 200500: Basic Requirements for Mechanical, Plumbing, and Fire Suppression**]
2. [**Section 200513: Common Motor Requirements for Mechanical, Plumbing, and Fire Suppression**]
3. [**Section 200517: Sleeves, Seals and Escutcheons for Mechanical, Plumbing, and Fire Suppression**]
4. [**Section 200519: Meters And Gauges for Mechanical, Plumbing, and Fire Suppression**]
5. [**Section 200523: General Duty Valves for Mechanical, Plumbing, and Fire Suppression**]
6. [**Section 200529: Hangers, Supports and Expansion Fittings for Mechanical, Plumbing, and Fire Suppression**]
7. [**Section 200553: Identification for Mechanical, Plumbing, and Fire Suppression Piping and Equipment**]
8. [**Section 200593: Testing, Adjusting and Balancing for Mechanical and Plumbing**]
9. [**Section 200700: Thermal Insulation for Mechanical, Plumbing, and Fire Suppression**]
10. [**Section 200800: Commissioning of Mechanical, Plumbing, and Fire Suppression Systems**]
11. [**Section 201101: Above-ground Piping for Mechanical, Plumbing, and Fire Suppression**]
12. [**Section 201102: Under-ground Piping for Mechanical, Plumbing, and Fire Suppression**]
13. [**Section 202923: Variable Frequency Motor Controllers for Mechanical and Plumbing**]

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 SCOPE

A. Work included under Divisions 20 and 23 shall include all labor, services, materials, and equipment and performance of all work required for installation of mechanical systems as shown on Drawings and as specified.

END OF SECTION

SECTION 23 01 30.51

HVAC AIR-DISTRIBUTION SYSTEM CLEANING

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 cleaning HVAC air-distribution equipment, ducts, plenums, and system components.

1.3 DEFINITIONS

A. ASCS: Air systems cleaning specialist.

B. NADCA: National Air Duct Cleaners Association.

1.4 QUALITY ASSURANCE

A. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.

B. Perform "Project Evaluation and Recommendation" according to NADCA ACR 2006.

C. Prepare written report listing conditions detrimental to performance of the Work.

D. Proceed with work only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare a written plan that includes strategies and step-by-step procedures. At a minimum, include the following:

1. Supervisor contact information.
2. Work schedule including location, times, and impact on occupied areas.
3. Methods and materials planned for each HVAC component type.
4. Required support from other trades.
5. Equipment and material storage requirements.
6. Exhaust equipment setup locations.

B. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.

C. Comply with NADCA ACR 2006, "Guidelines for Constructing Service Openings in HVAC Systems" Section.

3.3 CLEANING

A. Comply with NADCA ACR 2006.

B. Remove visible surface contaminants and deposits from within the HVAC system.

C. Systems and Components to Be Cleaned:

1. Air devices for supply and return air.
2. Air-terminal units.
3. Ductwork:

    a. Supply-air ducts, including turning vanes and reheat coils, to the air-handling unit.
    b. Return-air ducts to the air-handling unit.
    c. Exhaust-air ducts.

4. Air-Handling Units:

    a. Interior surfaces of the unit casing.
    b. Coil surfaces compartment.
    c. Condensate drain pans.
    d. Fans, fan blades, and fan housings.

5. Filters and filter housings.

D. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.

E. Particulate Collection:

1. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,

F. Control odors and mist vapors during the cleaning and restoration process.

G. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.

H. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.

I. Clean all air-distribution devices, registers, grilles, and diffusers.

J. Clean visible surface contamination deposits according to NADCA ACR 2006 and the following:

1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
2. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
3. Clean evaporator coils, reheat coils, and other airstream components.

K. Duct Systems:

1. Create service openings in the HVAC system as necessary to accommodate cleaning.
2. Mechanically clean duct systems specified to remove all visible contaminants so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).

L. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.

M. Mechanical Cleaning Methodology:

1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.

    a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
    b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.

2. Cleaning Mineral-Fiber Insulation Components:

    a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.
    b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
    c. Fibrous materials that become wet shall be discarded and replaced.

N. Coil Cleaning:

1. Measure static-pressure differential across each coil.
2. See NADCA ACR 2006, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing Coil Cleaning Verification (see applicable NADCA ACR 2006).
3. Coil drain pans shall be subject to NADCA ACR 2006, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
4. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
5. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations when available.
6. Rinse thoroughly with clean water to remove any latent residues.

O. Antimicrobial Agents and Coatings:

1. Apply antimicrobial agents and coatings if active fungal growth is reasonably suspected or where unacceptable levels of fungal contamination have been verified. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.

2. When used, antimicrobial treatments and coatings shall be applied after the system is rendered clean.
3. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.
4. Sanitizing agent products shall be registered by the EPA as specifically intended for use in HVAC systems and ductwork.

3.4 CLEANLINESS VERIFICATION

A. Verify cleanliness according to NADCA ACR 2006, "Verification of HVAC System Cleanliness" Section.

B. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents and coatings.

C. Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.

3.5 RESTORATION

A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR 2006, "Restoration and Repair of Mechanical Systems" Section.

B. Restore service openings capable of future reopening. Comply with requirements in Section 23 31 00 "Ductwork and HVAC Casings." Include location of service openings in Project closeout report.

C. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in 23 31 00 "Ductwork and HVAC Casings."

D. Replace damaged insulation according to Section 20 07 00 "Thermal Insulation for Mechanical, Plumbing and Fire Suppression."

E. Ensure that closures do not hinder or alter airflow.

F. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.

G. Reseal fibrous-glass ducts. Comply with requirements in Section 23 31 00 "Ductwork and HVAC Casings."

END OF SECTION

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SECTION 23 07 00

HVAC INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. HVAC piping insulation, jackets and accessories.
2. HVAC equipment insulation, jackets and accessories.
3. HVAC ductwork insulation, jackets, and accessories.

B. Related Sections:

1. Section 23 21 13 - Hydronic Piping: Product requirements for insulation of piping specified by this section.
2. Section 23 22 23 - Steam and Condensate Piping: Product requirements for insulation of piping specified by this section.
3. Section 23 23 00 - Refrigerant Piping: Product requirements for insulation of piping specified by this section.
4. Section 23 31 00 - HVAC Ducts and Casings: Product requirements for insulating ductwork specified by this section.

1.02 REFERENCES

A. ASTM International:

1. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
2. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
3. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
4. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
5. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
6. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
7. ASTM C450 - Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging.
8. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.

9. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

10. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.

11. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

12. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.

13. ASTM C585 - Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).

14. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.

15. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.

16. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.

17. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

18. ASTM C1071 - Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).

19. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

20. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.

21. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

22. ASTM D4637 - Standard Specification for EPDM Sheet Used in Single-Ply Roof Membrane.

23. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials.

24. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.

25. ASTM E 2336 (AC101); ' Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems Acceptance Criteria for Grease Duct Enclosures'.

26. ASTM E 814 (UL1479); ' Standard Test Method for Fire Tests of Through-Penetration Fire Stops'.

27. NFPA 96; ' Standard for Ventilation Control & Fire Protection of Commercial Cooking Operations'.

B. Sheet Metal and Air Conditioning Contractors':

1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

C. Underwriters Laboratories Inc.:

1. UL 1978 - Standard for Safety for Grease Ducts.

1.03 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Submittal procedures.

B. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.

C. Samples: Submit two samples of representative size illustrating each insulation type.

D. Manufacturer's Installation Instructions: Submit manufacturers published literature indicating proper installation procedures.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.04 QUALITY ASSURANCE

A. Test pipe insulation for maximum flame spread index of 25/50 and maximum smoke developed index of not exceeding in accordance with ASTM E84.

B. Pipe insulation manufactured in accordance with ASTM C585 for inner and outer diameters.

C. Factory fabricated fitting covers manufactured in accordance with ASTM C450.

D. Duct insulation, Coverings, and Linings: Maximum 25/50 flame spread/smoke developed index, when tested in accordance with ASTM E84, using specimen procedures and mounting procedures of ASTM E 2231.

E. Perform Work in accordance with State of New York Standards.

F. Maintain one copy of each document on site.

1.05 QUALIFICATIONS

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

1.06 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

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

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

1.07 ENVIRONMENTAL REQUIREMENTS

A. Section 01 60 00 - Product Requirements: Environmental conditions affecting products on site.

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

1.08 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.09 WARRANTY

A. Section 01 70 00 - Execution Requirements: Product warranties and product bonds.

PART 2 - PRODUCTS

2.01 PIPE INSULATION

A. Type P-1: ASTM C547, molded glass fiber pipe insulation. Conform to ASTM C795 for application on Austenitic stainless steel.

1. Thermal Conductivity: 0.23 at 75 degrees F (0.034 at 24 degrees C).
2. Operating Temperature Range: 0 to 850 degrees F (minus 18 to 454 degrees C).
3. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied reinforced foil Kraft with self-sealing adhesive joints.
4. Jacket Temperature Limit: minus 20 to 150 degrees F (minus 29 to 66 degrees C).

B. Type P-2: ASTM C547, molded glass fiber pipe insulation. Conform to ASTM C795 for application on Austenitic stainless steel.

1. Thermal Conductivity: 0.23 at 75 degrees F (0.034 at 24 degrees C).
2. Operating Temperature Range: 0 to 850 degrees F (minus 18 to 454 degrees C).

C. Type P-3: ASTM C612; semi-rigid, fibrous glass board noncombustible, end grain adhered to jacket. Conform to ASTM C795 for application on Austenitic stainless steel.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.040 at 24 degrees C).
2. Operating Temperature Range: 0 to 650 degrees F (minus 18 to 343 degrees C).
3. Vapor Barrier Jacket: ASTM C1136, Type II, factory applied reinforced foil Kraft with self-sealing adhesive joints.
4. Jacket Temperature Limit: minus 20 to 150 degrees F (minus 29 to 66 degrees C).

D. Type P-4: ASTM C612; semi-rigid, fibrous glass board noncombustible. Conform to ASTM C795 for application on Austenitic stainless steel.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.040 at 24 degrees C).

2. Operating Temperature Range: 0 to 650 degrees F (minus 18 to 343 degrees C).

E. Type P-5: ASTM C534, Type I, flexible, closed cell elastomeric insulation, tubular.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 25 degrees C).

2. Operating Temperature Range: Range: Minus 70 to 180 degrees F (minus 57 to 82 degrees C).

F. Type P-6: ASTM C534, Type I, flexible, closed cell elastomeric insulation, tubular.

1. Thermal Conductivity: 0.30 at 75 degrees F (0.043 at 24 degrees C).

2. Maximum Service Temperature: 300 degrees F (149 degrees C).

3. Operating Temperature Range: Range: Minus 58 to 300 degrees F (minus 50 to 149 degrees C).

G. Type P-7: ASTM C534, Type I, flexible, non-halogen, closed cell elastomeric insulation, tubular.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 24 degrees C).

2. Maximum Service Temperature: 250 degrees F (120 degrees C).

3. Operating Temperature Range: Range: Minus 58 to 250 degrees F (minus 50 to 120 degrees C).

H. Type P-8: ASTM C547, Type I or II, mineral fiber preformed pipe insulation, noncombustible.

1. Thermal Conductivity: 0.23 at 75 degrees F (0.034 at 24 degrees C).

2. Maximum Service Temperature: 1200 degrees F (649 degrees C).

3. Canvas Jacket: UL listed, 6 oz./sq. yd. (220 g/sq. m), plain weave cotton fabric treated with fire retardant lagging adhesive.

I. Type P-9: ASTM C591, Type IV, polyisocyanurate foam insulation, formed into shapes for use as pipe insulation.

1. Density: 4.0 pounds per cubic foot (64 kg per cubic meter).

2. Thermal Conductivity: 180 day aged value of 0.20 at 75 degrees F (0.029 at 24 degrees C).

3. Operating Temperature Range: Range: Minus 297 to 300 degrees F (minus 183 to 149 degrees C).

4. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied film of 6 mils (0.15 mm) thickness and water vapor permeance of 0.02 perms.

J. Type P-10: ASTM C578, Type XIII, extruded polystyrene insulation, formed into shapes for use as pipe insulation.

1. Thermal Conductivity: 180 day aged value of 0.259 at 75 degrees F (0.037 at 24 degrees C).

2. Operating Temperature Range: Range: Minus 297 to 165 degrees F (minus 183 to 74 degrees C).

3. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied film of 6 mils (0.15 mm) thickness and water vapor permeance of 0.02 perms.

K. Type P-11: ASTM C533; Type I, hydrous calcium silicate pipe insulation, rigid molded white; asbestos free.

1. Thermal Conductivity: 0.45 at 200 degrees F (0.0650 at 93 degrees C).

2. Operating Temperature Range: 140 to 1200 degrees F (60 to 649 degrees C).

2.02 PIPE INSULATION JACKETS

A. Vapor Retarder Jacket:

1. ASTM C921, white Kraft paper with glass fiber yarn, bonded to aluminized film.

2. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms (290 ng/Pa/s/m).

B. PVC Plastic Pipe Jacket:

1. Product Description: ASTM D1785, One piece molded type fitting covers and sheet material, off-white color.

2. Thickness15 mil (0.38 mm).

3. Connections: Brush on welding adhesive, Tacks.

C. ABS Plastic Pipe Jacket:

1. Jacket: One piece molded type fitting covers and sheet material, off-white color.

2. Minimum service temperature: -40 degrees F (-40 degrees C).

3. Maximum service temperature of 180 degrees F (82 degrees C).

4. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms (174 ng/Pa/s/m).

5. Thickness: 30 mil (0.76 mm).

6. Connections: Brush on welding adhesive.

D. Aluminum Pipe Jacket:

1. ASTM B209 (ASTM B209M).

2. Thickness: 0.025 inch (0.64 mm) thick sheet.

3. Finish: Embossed.

4. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.

5. Fittings: 0.016 inch (0.4 mm) thick die shaped fitting covers with factory attached protective liner.

6. Metal Jacket Bands: 1/2 inch (13 mm) wide; 0.015 inch thick aluminum.

E. Stainless Steel Pipe Jacket:

1. ASTM A240/A240M OR ASTM 666 Type 304 stainless steel.

2. Thickness: 0.016 inch (0.40 mm) thick.

3. Finish: Smooth.

4. Metal Jacket Bands: 1/2 inch (13 mm) wide; 0.020 inch thick stainless steel.

2.03 PIPE INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Covering Adhesive Mastic: Compatible with insulation.

C. Piping 1-1/2 inches (40 mm) diameter and smaller: Galvanized steel insulation protection shield. MSS SP-69, Type 40. Length: Based on pipe size and insulation thickness.

D. Piping 2 inches (50 mm) diameter and larger: Wood insulation saddle, hard maple. Inserts length: not less than 6 inches (150 mm) long, matching thickness and contour of adjoining insulation.

E. Closed Cell Elastomeric Insulation Pipe Hanger: Polyurethane insert with aluminum jacket single piece construction with self-adhesive closure. Thickness to match pipe insulation.

F. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.

G. Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement: ASTM C449/C449M.

H. Insulating Cement: ASTM C195; hydraulic setting on mineral wool.

I. Adhesives: Compatible with insulation.

2.04 EQUIPMENT INSULATION

A. Type E-1: ASTM C553; glass fiber, flexible or semi-rigid, noncombustible.

1. Thermal Conductivity: 0.023 at 75 degrees F.
2. Operating Temperature Range: 0 to 450 degrees F.
3. Density: 1.65 pound per cubic foot.

B. Type E-2: ASTM C612; glass fiber, rigid board, noncombustible with factory applied Kraft aluminum foil jacket.

1. Thermal Conductivity: 0.023 at 75 degrees F (0.032 at 24 degrees C).
2. Operating Temperature Range: 0 to 450 degrees F (minus 18 to 232 degrees C).
3. Density: 4.2 pound per cubic foot (67 kilogram per cubic meter).
4. Jacket Temperature Limit: minus 20 to 150 degrees F (minus 29 to 66 degrees C).

C. Type E-3: ASTM C612; semi-rigid, fibrous glass board noncombustible, end grain adhered to jacket.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.040 at 24 degrees C).
2. Operating Temperature Range: 0 to 650 degrees F (minus 18 to 343 degrees C).
3. Vapor Barrier Jacket: ASTM C1136, Type II, factory applied reinforced foil Kraft with self-sealing adhesive joints.
4. Jacket Temperature Limit: minus 20 to 150 degrees F (minus 29 to 66 degrees C).

D. Type E-4: ASTM C612; semi-rigid, fibrous glass board noncombustible.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.040 at 24 degrees C).
2. Operating Temperature Range: 0 to 650 degrees F (minus 18 to 343 degrees C).

E. Type E-5: ASTM C612; glass fiber, semi-rigid board, noncombustible.
1. Thermal Conductivity: 0.23 at 75 degrees F (0.033 at 24 degrees C).
2. Maximum Operating Temperature: 850 degrees F (450 degrees C).
3. Density: 3.0 pound per cubic foot (48 kilogram per cubic meter).

F. Type E-6: ASTM C553; mineral fiber blanket, Type I.
1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 24 degrees C).
2. Maximum Operating Temperature: 1000 degrees F (538 degrees C).
3. Density: 1.0 pound per cubic foot (16 kilogram per cubic meter).

G. Type E-7: ASTM C533; Type II, hydrous calcium silicate block insulation, asbestos free.
1. Thermal Conductivity: 0.45 at 200 degrees F (0.0650 at 93 degrees C).
2. Operating Temperature Range: 140 to 1200 degrees F (60 to 649 degrees C).

H. Type E-8: ASTM C534, Type II, flexible, closed cell elastomeric insulation, sheet.
1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 25 degrees C).
2. Operating Temperature Range: Range: Minus 70 to 220 degrees F (minus 57 to 105 degrees C).

I. Type E-9: ASTM C612, man-made mineral fiber, noncombustible, Classes 1-4.
1. Thermal Conductivity: 0.25 at 100 degrees F (0.037 at 38 degrees C).
2. Maximum Service Temperature: 1200 degrees F (650 degrees C).
3. Density: 8 pound per cubic foot (128 kilogram per cubic meter).

2.05 EQUIPMENT INSULATION JACKETS

A. PVC Plastic Equipment Jacket:
1. Product Description: ASTM D1785, sheet material, off-white color.
2. Minimum Service Temperature: -40 degrees F (-40 degrees C).
3. Maximum Service Temperature: 150 degrees F (66 degrees C).
4. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms (290 ng/Pa/s/m).
5. Thickness: 20 mil (0.50 mm).
6. Connections: Brush on welding adhesive, Tacks, and pressure sensitive color matching vinyl tape.

B. Aluminum Equipment Jacket:
1. ASTM B209 (ASTM B209M)Thickness: 0.020 inch (0.50 mm) thick sheet.
2. Finish: Embossed.
3. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.
4. Fittings: 0.016 inch (0.4 mm) thick die shaped fitting covers with factory attached

protective liner.

5. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.015 inch (0.38 mm) thick aluminum.

C. Stainless Steel Equipment Jacket:

1. ASTM A240/A240M OR ASTM 666 Type 304 stainless steel.

2. Thickness: 0.016 inch (0.40 mm) thick.

3. Finish: Corrugated.

4. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.010inch thick stainless steel.

D. Canvas Equipment Jacket: UL listed, 6 oz./sq. yd. (220 g/sq. m), plain weave cotton fabric with fire retardant lagging adhesive compatible with insulation.

E. Vapor Retarder Jacket:

1. ASTM C921, white Kraft paper with glass fiber yarn, bonded to aluminized film.

2. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms (290 ng/Pa/s/m).

F. Field Applied Glass Fiber Fabric Jacket System:

1. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2. Glass Fiber Fabric:
   a. Cloth: Untreated; 9 oz./sq. yd. (305 g/sq. m) weight.
   b. Blanket: 1.0 lb./cu ft. (16 kg/cu m) density.
   c. Weave: 10 x 10.

3. Indoor Vapor Retarder Finish:
   a. Cloth: Untreated; 9 oz./sq. yd. (305 g/sq. m) weight.
   b. Vinyl emulsion type acrylic, compatible with insulation, white color.

2.06 EQUIPMENT INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Covering Adhesive Mastic: Compatible with insulation.

C. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.

D. Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement: ASTM C449/C449M.

E. Adhesives: Compatible with insulation.

2.07 DUCTWORK INSULATION

A. Type D-1: ASTM C1290, Type III, flexible glass fiber, commercial grade with factory applied reinforced aluminum foil jacket meeting ASTM C1136, Type II.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 24 degrees C).

2. Maximum Operating Temperature: 250 degrees F (121 degrees C).

3. Density: 1.0 pound per cubic foot (16 kilogram per cubic meter).

B. Type D-2: ASTM C612, Type IA or IB, rigid glass fiber, with factory applied all service facing reinforced aluminum foil facing meeting ASTM C1136, Type II.

1. Thermal Conductivity: 0.23 at 75 degrees F (0.033 at 24 degrees C).
2. Density: 3.0 pound per cubic foot (48 kilogram per cubic meter).

C. Type D-3: ASTM C612, Type IA or IB, rigid glass fiber, no facing.

1. Thermal Conductivity: 0.23 at 75 degrees F (0.033 at 24 degrees C).
2. Density:3.0 pound per cubic foot (48 kilogram per cubic meter).

D. Type D-4: ASTM C1071, Type I, flexible, glass fiber duct liner with coated air side.

1. Thermal Conductivity: 0.25 at 75 degrees F (0.036 at 24 degrees C).
2. Density: 2.75 pound per cubic foot (44 kilogram per cubic meter).
3. Maximum Operating Temperature: 250 degrees F (121 degrees C).
4. Maximum Air Velocity: 6,000 feet per minute (30.5 meter per second).

E. Type D-5: ASTM C1071, Type II, rigid, glass fiber duct liner with coated air side.

1. Thermal Conductivity: 0.23 at 75 degrees F (0.033 at 24 degrees C).
2. Density: 3.0 pound per cubic foot (48 kilogram per cubic meter).
3. Maximum Operating Temperature: 250 degrees F (121 degrees C).
4. Maximum Air Velocity: 4,000 feet per minute (20.3 meter per second).

F. Type D-6: ASTM C534, Type II, flexible, closed cell elastomeric insulation, sheet.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 24 degrees C).
2. Service Temperature Range: Range: Minus 58 to 180 degrees F (minus 50 to 82 degrees C).

G. Type D-7: ASTM C534, Type II, flexible, closed cell elastomeric insulation, sheet laminated with white thermoplastic rubber membrane.

1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 24 degrees C).
2. Service Temperature Range: Range: - 58 to 180 degrees F (minus 50 to 82 degrees C).

H. Type D-8: Thermal Material: 2192 degree F rated core blanket, manufactured from patented bio-soluble Superwool chemistry (Calcium Magnesium Silicate).

1. Product: FireMaster FastWrap XL by Thermal Ceramics or approved equal.
2. Fully encapsulated thermal material in fiberglass reinforced aluminum/polypropylene scrim (FSP).
   a. Encapsulation FSP marked with UL Classification Mark.
   b. Encapsulation FSP marked with ICC-ES report number ESR 2213 or ESR 2832.
   c. Collars supplied in 6 inch (150 mm) wide by 25 feet (7620 mm) long rolls.
3. Product Characteristics:
   a. Thickness: 1-1/2 inch (38 mm).
   b. Nominal Density: 6 pcf.
   c. R-Value: 7.35 per layer of FireMaster FastWrap XL.

d. Flame Spread: < 25 when tested in accordance with ASTM E 84.
e. Smoke Development: < 50 when tested in accordance with ASTM E 84.

I. Type D-9: Inorganic blanket encapsulated with scrim reinforced foil meeting UL 1978.

1. Thermal Conductivity: 0.42 at 500 degrees F (0.060 at 260 degrees C).

2. Weight: 1.4 pound per square foot (6.73 kilogram per square meter).

3. Surface Burning Characteristics: Maximum 0/0 flame spread/smoke developed index when tested in accordance with ASTM E84.

2.08 DUCTWORK INSULATION JACKETS

A. Aluminum Duct Jacket:

1. ASTM B209.

2. Thickness:0.025 inch (0.64 mm) thick sheet.

3. Finish: Smooth.

4. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.

5. Fittings: 0.016 inch (0.4 mm) thick die shaped fitting covers with factory attached protective liner.

6. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.015 inch (0.38 mm) thick aluminum.

B. Vapor Retarder Jacket:

1. Kraft paper with glass fiber yarn and bonded to aluminized film 0.0032 inch (0.081 mm) vinyl.

2. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms (290 ng/Pa/s/m).

3. Secure with pressure sensitive tape.

C. Canvas Duct Jacket: UL listed, 6 oz./sq. yd. (220 g/sq. m), plain weave cotton fabric with fire retardant lagging adhesive compatible with insulation.

D. Outdoor Duct Jacket: Asphalt impregnated and coated sheet, 50 lb./square (2.45 kg/sq. m).

E. Membrane Duct Jacket: ASTM D4637; Type I, EPDM; non-reinforced, 0.060 inch (1.5 mm) thick, 48 inch (1220 mm) wide roll; white color.

2.09 DUCTWORK INSULATION ACCESSORIES

A. Vapor Retarder Tape:

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

B. Vapor Retarder Lap Adhesive: Compatible with insulation.

C. Adhesive: Waterproof, ASTM E162 fire-retardant type.

D. Liner Fasteners: Galvanized steel, self-adhesive pad, impact applied, welded with integral press-on head.

E. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.

F. Lagging Adhesive: Fire retardant type with maximum 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.

G. Impale Anchors: Galvanized steel, 12 gage self-adhesive pad.

H. Adhesives: Compatible with insulation.

I. Membrane Adhesives: As recommended by membrane manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Verify piping, equipment and ductwork has been tested before applying insulation materials.

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

3.02 INSTALLATION - PIPING SYSTEMS

A. Piping Exposed to View in Finished Spaces: Locate insulation and cover seams in least visible locations.

B. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent firestopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions. Refer to Section 07 84 00 for penetrations of assemblies with fire resistance rating greater than one hour.

C. Piping Systems Conveying Fluids Below Ambient Temperature:

1. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

2. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.

3. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor retarder adhesive or PVC fitting covers.

D. Glass Fiber Board Insulation:

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

2. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.

3. Cover wire mesh or bands with cement to a thickness to remove surface irregularities.

E. Polyisocyanurate Foam Insulation:

1. Wrap elbows and fitting with vapor retarder tape.

2. Seal butt joints with vapor retarder tape.

F. Hot Piping Systems less than 140 degrees F (60 degrees C):

1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.

2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.

3. Do not insulate unions and flanges at equipment, but bevel and seal ends of insulation at such locations.

G. Hot Piping Systems greater than 140 degrees F (60 degrees C):

1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.

2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.

3. Insulate flanges and unions at equipment.

H. Inserts and Shields:

1. Piping 1-1/2 inches (40 mm) Diameter and Smaller: Install galvanized steel shield between pipe hanger and insulation.

2. Piping 2 inches (50 mm) Diameter and Larger: Install insert between support shield and piping and under finish jacket.
   a. Insert Configuration: Minimum 6 inches (150 mm) long, of thickness and contour matching adjoining insulation; may be factory fabricated.
   b. Insert Material: Compression resistant insulating material suitable for planned temperature range and service.

3. Piping Supported by Roller Type Pipe Hangers: Install galvanized steel shield between roller and inserts.

I. Insulation Terminating Points:

1. Coil Branch Piping 1 inch (25 mm) and Smaller: Terminate hot water piping at union upstream of the coil control valve.

2. Chilled Water Coil Branch Piping: Insulate chilled water piping and associated components up to coil connection.

3. Condensate Piping: Insulate entire piping system and components to prevent condensation.

J. Closed Cell Elastomeric Insulation:

1. Push insulation on to piping.

2. Miter joints at elbows.

3. Seal seams and butt joints with manufacturer's recommended adhesive.

4. When application requires multiple layers, apply with joints staggered.

5. Insulate fittings and valves with insulation of like material and thickness as adjacent pipe.

K. High Temperature Pipe Insulation:

1. Install in multiple layers to meet thickness scheduled.

2. Attach each layer with bands. Secure first layer with bands before installing next layer.

3. Stagger joints between layers.

4. Finish with canvas jacket sized for finish painting.

L. Piping Exterior to Building: Provide vapor retarder jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor retarder cement. Cover with aluminum jacket with seams located at 3 or 9 o'clock position on side of horizontal piping with overlap facing down to shed water or on bottom side of horizontal piping.

M. Buried Piping: Insulate only where insulation manufacturer recommends insulation product may be installed in trench, tunnel or direct buried. Install factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with 1 mil (0.025 mm) thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with polyester film.

N. Heat Traced Piping Interior to Building: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer.

O. Heat Traced Piping Exterior to Building: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size insulation large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located at 3 or 9 o'clock position on side of horizontal piping with overlap facing down to shed water.

P. Prepare pipe insulation for finish painting. Refer to Section 09 90 00.

3.03 INSTALLATION - EQUIPMENT

A. Factory Insulated Equipment: Do not insulate.

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

C. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.

D. Equipment Containing Fluids Below Ambient Temperature:

1. Insulate entire equipment surfaces.

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

3. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.

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

E. Equipment Containing Fluids 140 degrees F (60 degrees C) or Less:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation.

2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.

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

F. Equipment Containing Fluids Over 140 degrees F (60 degrees C):

1. Insulate flanges and unions with removable sections and jackets.

2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.

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

G. Equipment Located Exterior to Building: Install vapor barrier jacket or finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal equipment.

H. Nameplates and ASME Stamps: Bevel and seal insulation around; do not cover with insulation.

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

J. Prepare equipment insulation for finish painting. Refer to Section 09 90 00.

3.04 INSTALLATION - DUCTWORK SYSTEMS

A. Duct dimensions indicated on Drawings are finished inside dimensions.

B. Insulated ductwork conveying air below ambient temperature:

1. Provide insulation with vapor retarder jackets.

2. Finish with tape and vapor retarder jacket.

3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.

4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

C. Insulated ductwork conveying air above ambient temperature:

1. Provide with or without standard vapor retarder jacket.

2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

D. Ductwork Exposed in Mechanical Equipment Rooms or Finished Spaces (below 10 feet (3 meters) above finished floor): Finish with canvas jacket sized for finish painting.

E. External Glass Fiber Duct Insulation:

1. Secure insulation with vapor retarder with wires and seal jacket joints with vapor retarder adhesive or tape to match jacket.
2. Secure insulation without vapor retarder with staples, tape, or wires.
3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
4. Seal vapor retarder penetrations by mechanical fasteners with vapor retarder adhesive.
5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

F. External Elastomeric Duct Insulation:

1. Adhere to clean oil-free surfaces with full coverage of adhesive.
2. Seal seams and butt joints with manufacturer's recommended adhesive.
3. When application requires multiple layers, apply with joints staggered.
4. Insulate standing metal duct seams with insulation of like material and thickness as adjacent duct surface. Apply adhesive at joints with flat duct surfaces.
5. Lift ductwork off trapeze hangers and insert spacers.

G. Duct and Plenum Liner:

1. Adhere insulation with adhesive for 90 percent coverage.
2. Secure insulation with mechanical liner fasteners. Comply with SMACNA Standards for spacing.
3. Seal and smooth joints. Seal and coat transverse joints.
4. Seal liner surface penetrations with adhesive.
5. Cut insulation for tight overlapped corner joints. Support top pieces of liner at edges with side pieces.

H. Kitchen Exhaust Ductwork:

1. Cover duct by wrapping with insulation using overlap method.
2. Overlap seams of each method by 3 inches (76 mm).
3. Attach insulation using steel banding or by welded pins and clips.
4. Install insulation without sag on underside of ductwork. Use additional fasteners to prevent sagging.

I. Ducts Exterior to Building:

1. Install insulation according to external duct insulation, paragraph above.
2. Provide external insulation with vapor retarder jacket. Cover with outdoor jacket finished with caulked aluminum jacket with seams located on bottom side of horizontal duct section.
3. Finish with aluminum duct jacket.

4. Calk seams at flanges and joints. Located major longitudinal seams on bottom side of horizontal duct sections.

J. Prepare duct insulation for finish painting. Refer to Section 09 90 00.

3.05 SCHEDULES

A. Cooling Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches
Chilled Water Supply and Return 40 to 60 degrees F	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	0.5 1.0
Chilled Water Suppl and Return (less than 40 degrees F)	P-1	¾ inch and smaller 1 inch to 6 inches 8 inches and larger	0.5 1.0 1.5
Glycol Supply and Return 40 to 60 degrees F	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	0.5 1.0
Condenser Water 60 to 100 degrees F	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	1.0 1.5
Condenser Water 60 to 100 degrees F	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	1.0 1.5
Condensate Piping from Cooling Coils	P-5	1-1/4 inches and smaller 1-1/2 inches and larger	0.5 1.0
Refrigerant Section	P-5	All Sizes	1.0
Refrigerant Gas	P-5	All Sizes	1.0

B. Heating Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches
Heating Water Supply and return (105 to 140 degrees F)	P-1	1-1/4 inches and smaller 1-1/2 inches inch and larger	1.0 1.5

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches
Heating Water supply and Return 141 to 200 degrees F	P-1	1-1/4 inches and smaller 1-1/2 inches and larger.	1.5 2.0
Heating Water Supply and Return (201 to 250 degrees F)	P-1	3 inches and smaller 4 inches inch and larger	2.5 3.0
Low Pressure Steam Supply up to 15 psi up to 250 degrees F	P-1	3 inches and smaller 4 inches and larger	2.5 3.0
Medium Pressure Steam Supply 16 to 119 psi (251 to 350 degrees F)	P-8	3/4 inch and smaller 1 inch to 1-1/4 inches 1-1/2 inches and larger	3.0 4.0 4.5
High Pressure Steam Supply 120 psi and higher 350 degrees F	P-8	3/4 inch and smaller 1 inch and larger	4.5 5.0
Low Pressure Steam Condensate Return	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	2.5 3.0
High Pressure Steam Condensate Return	P-1	3/4 inches and smaller 1 inches and larger	4.5 5.0
Gravity Steam Condensate Return	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	2.5 3.0
Pumped Steam Condensate Return	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	2.5 3.0
Boiler Feed Water	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	2.5 3.0
Humidifier Supply Piping	P-1	1-1/4 inches and smaller 1-1/2 inches and larger	1.5 2.0
Humidifier Drain Piping	P-1	All sizes	1.0

C. Equipment Insulation Schedule:

EQUIPMENT	INSULATION TYPE	INSULATION THICKNESS inches
Steam-to-Water Heat Exchanger	E-2	3.0
Water-to-Water Heat Exchangers	E-2	2.0

Hot Thermal Storage Tanks	E-2	2.0
Boiler and Feed Water Storage Tanks	E-2	2.0
Steam Condensate Receivers	E-2	2.0
Condensate Tanks	E-2	2.0
Deaerators	E-2	2.0
Boiler Breeching	E-5	3.0
Chilled Water Pump Bodies	E-8	1.0
Chilled Water Air Separators	E-8	1.0
Chilled Water Expansion Tanks	E-8	1.0
Chiller Cold Surfaces (Not Factory Insulated)	E-8	1.0
Absorption Chiller Hot Surfaces (Not Factory Insulated)	E-5	1.0
Cold Thermal Storage Tanks	E-8	1.0
Generator Exhaust Piping	E-7 or E-9	4.0
Generator Exhaust Muffler	E-7 or E-9	5.0

D. Ductwork Insulation Schedule:

DUCTWORK SYSTEM	**INSULATION TYPE**	**INSULATION THICKNESS inches**
Combustion Air	D-2	2.0
Outside Air Intake	D-2	2.0
Equipment Casings	D-2	2.0
Supply Ducts (Externally Insulated) thickness indicated is installed thickness.	D-1	2.0
Return Ducts (Externally Insulated) thickness indicated is installed thickness.	D-1	2.0

DUCTWORK SYSTEM	INSULATION TYPE	INSULATION THICKNESS inches
Supply Ducts (Internally Insulated), required where indicated on drawings)	D-5	2.0
Return Ducts (Internally Insulated), required where indicated on drawings)	D-5	2.0
Duct Coils	D-1	2.0
Kitchen Exhaust Duct (2 layers of 1-1/2 inch (40 mm) each)	D-8	3.0
Exterior Supply Air, Return Air, Exhaust Air (Exterior to Building on Roof)	D-2	2.5
Evaporative Condenser Intake and Exhaust thickness indicated is installed thickness.	D-1	2.5
Exhaust Ducts within 10 feet (3 mm) of exterior openings thickness indicated is installed thickness.	D-1	1.5
Round Supply Ducts Downstream of Variable Air Volume Boxes (Externally Insulated)	D-2	2.0
Transfer Air Ducts (Internally Insulated)	D-5	2.0

END OF SECTION

SECTION 23 09 23.16

GAS INSTRUMENTS

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 Gas Instruments:
   1. Multipoint carbon-monoxide monitoring system.

B. Related Requirements:

   1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.16.

1.3 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.4 SUBMITTALS

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

   1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   2. Installation instructions, including factor affecting performance.
   3. Product description with complete technical data, performance curves, product specification sheets.

B. Shop Drawings:

   1. Include plans, elevations, sections, and mounting details.

2. Include diagrams for power, signal, and control wiring.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MULTIPOINT CARBON-MONOXIDE MONITORING SYSTEM

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

1. MSA Instrument Division; MultiGard.

B. Description:

1. Each sampling point shall monitor any variation in the carbon-monoxide concentration level.
2. Each sampling point shall be individually piped to the monitoring system.
3. Provide each sampling point with a 0.3-micron filter.
4. Each sampling point shall be an alarm point.
5. A dual-head diaphragm pump shall draw an air sample through piping system and through a microprocessor-controlled sequencer feeding an analyzer with a new sample every 15 seconds.
6. Sample time shall be adjustable in 1 second increments from zero to 60 minutes.
7. Span and zero calibration gas shall be automatically initiated by the microprocessor. System shall also provide manual initiation of span and zero calibration gas.
8. Analyzer output shall be corrected by the microprocessor.
9. Monitoring system shall have 16 or 24 sample points.
10. System shall operate on 120-V ac, single-phase, 60-Hz power.
11. Final adjustment; calibration, testing, and startup of the system shall be performed by a trained representative of manufacturer.

C. Analyzer:

1. Analyzer shall operate using principle of nondispersive infrared absorption.
2. Sampling response time shall be within 10 seconds.
3. Zero drift and span drift shall be less than 1 percent of full scale within a 24-hour period.
4. Repeatability shall be within 1 percent of full scale.
5. Accuracy shall be within 1 percent of full scale.
6. Calibration range shall be zero to 500 ppm.
7. Digital display on analyzer face with scale shall be in ppm.
8. Temperature shall be compensated from 30 to 120 deg F((minus 1 to 49 deg C)) ambient temperature.

D. Control and Display:

1. Each sample shall send a 4-20 mA output signal proportional to the highest concentration.
2. Alphanumeric visual display of current analyzer concentration reading shall be in ppm or another industry-accepted measurement.
3. Visual indication for sample analyzing, sample high-concentration alarm, analyzer malfunction, and calibration.
4. Any number and configuration of sample points shall be capable of being bypassed.
5. Each sample point shall be capable of being manually sampled through an override feature.
6. System parameters shall be stored in nonvolatile memory.
7. Provide at least an eight-hour battery backup of current alarm status. Battery shall be rechargeable.

E. Enclosure:

1. NEMA 250, Type 1.
2. Hinged and locking door, full size of face.
3. House all system components. Multiple adjoining enclosures are acceptable if joined to a common support structure.

F. Calibration Equipment:

1. Provide equipment necessary to automatically and manually calibrate the system, including, but not be limited to, the following:

    a. Regular assembly.
    b. Zero cap.
    c. Calibration cap.
    d. Two cylinders filled with calibration gas.
    e. Instruction book.
    f. Carrying case.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches((1.1 to 1.6 m)) above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches((1.5 m)).

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 CARBON-MONOXIDE MONITORING SYSTEM

A. Install sample points in monitored area to provide accurate measurement of gas concentration.

B. Install exposed sampling points with a finished appearance consistent with other materials in space. Submit proposed products to be installed for review and approval.

C. Individually install each sample point to the carbon-monoxide monitoring system.

D. Install tubing in a minimum size of NPS 3/8 (DN 10).

E. Use compression fittings at connections to equipment.

F. If not indicated on Drawings, locate carbon-monoxide monitoring system in a secured and serviceable location accessible to authorized personnel.

G. Support carbon-monoxide monitoring system from floor or wall. Support floor-mounted systems using a structural channel frame. Provide mounting brackets.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.7 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example,

an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

F. Switches: Calibrate switches to make or break contact at set points indicated.

G. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION

SECTION 23 09 23.23

PRESSURE INSTRUMENTS

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. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.

B. Related Requirements:

1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a control, asset management, safety, or other system using any control platform.

1.4 SUBMITTALS

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

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and [**mounting**] details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Product Certificates: For each product requiring a certificate.

D. Source quality-control reports.

E. Field quality-control reports.

F. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument-installed location shall dictate following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 12.
    b. Indoors, Heated with Filtered Ventilation: Type 1
    c. Indoors, Heated with Nonfiltered Ventilation: Type 2.
    d. Indoors, Heated and Air-Conditioned: Type 1.

e. Localized Areas Exposed to Washdown: Type 4.
f. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
g. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

2.2 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Indicating Switch:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Dwyer Instruments, Inc; Series 3000.

2. Combination gage with low- and high-limit switches.
3. Nominal 4-inch-(100-mm-) diameter analog indication with white dial face, graduated black markings, pointer to indicate measured value, and a separate adjustable pointer for each switch set point.
4. Switch zero and set-point adjustment screws or knobs on the dial face.
5. Each switch used as a safety limit shall have a manual reset button local to switch.
6. Switch Type: Each set point shall have two Form C relays, DPDT.
7. Electrical Connections: Screw terminals.
8. Enclosure Conduit Connection: NPS 3/4 (DN 20) threaded connection.
9. High and Low Process Connections: Threaded, NPS 1/8 (DN 6).
10. Enclosure:

    a. Dry Indoor Installations: NEMA 250, Type 1.
    b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
    c. Hazardous Environments: Explosion proof.

11. Operating Data:

    a. Electrical Rating: 10 A at 120- to 240-V ac.
    b. Pressure Limits: 25 psig (172 kPa).
    c. Temperature Limits: 20 to 120 deg F (Minus 7 to 49 deg C).
    d. Operating Range: Approximately twice normal operating range unless otherwise required for application.
    e. Accuracy:

        1) 4 percent for ranges through 0.5 in. w.g. (125 Pa).
        2) 2 percent for ranges 1 in. w.g. (250 Pa) and greater.

    f. Repeatability: Within 1 percent of full scale.
    g. Switch Deadband: One pointer width and within 1 percent of full scale for each switch set point.
    h. Power Supply: [**24**] [**or**] [**120**]-V ac, 50/60 Hz.

i. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

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

   a. Setra System; Model 267.
   b. Ashcroft's "Model XLDP."

2. Performance:

   a. Range: Approximately 2 times set point.
   b. Accuracy: Within 0.5 percent of the full-scale range.
   c. Hysteresis: Within 0.10 percent of full scale.
   d. Repeatability: Within 0.05 percent of full scale.
   e. Stability: Within 1 percent of span per year.
   f. Overpressure: 10 psig (69 kPa).
   g. Temperature Limits: Zero to 150 deg F (Minus 18 to 66 deg C).
   h. Compensate Temperature Limits: 40 to 150 deg F (4 to 66 deg C).
   i. Thermal Effects: 0.033 percent of full scale per degree F.
   j. Shock and vibration shall not harm the transmitter.

3. Output Signals:

   a. Analog Current Signal:

      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 800-ohm load.

   b. Analog Voltage Signal:

      1) Three wire, zero to [**5**][**10**] V.
      2) Minimum Load Resistance: 1000 ohms.

4. Display: Four-digit digital display with minimum 0.4-inch-(10-mm-) high numeric characters.
5. Operator Interface: Zero and span adjustments located behind cover.
6. Construction:

   a. Plastic casing with removable plastic cover.
   b. Threaded, NPS 1/4 (DN 10) swivel fittings for connection to copper tubing or NPS 3/16 (DN 7) barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
   c. Screw terminal block for wire connections.
   d. Vertical plane mounting.

e. NEMA 250, Type 4.
f. Provide mounting bracket suitable for installation.

B. Air Pressure Differential Transmitter:

1. Products: Subject to compliance with requirements, [**provide the following**][**provide one of the following**][**available products that may be incorporated into the Work include, but are not limited to, the following**]:

a. Ashcroft Inc; Model iXLDP.

2. FM Approved for hazardous environments. Intrinsically safe for Classes I, II, and III, Divisions 1 and 2, Groups A through H.
3. Performance:

a. Range: Approximately 2 times set point.
b. Accuracy: Within 0.5 percent of the span at reference temperature of 70 deg F (21 deg C).
c. Hysteresis: Within 0.02 percent of the span.
d. Repeatability: Within 0.05 percent of the calibrated span.
e. Stability: Within 0.25 percent of span per year.
f. Overpressure: 20 psig (138 kPa).
g. Temperature Limits: Minus 20 to 185 deg F (Minus 29 to 85 deg C).
h. Compensate Temperature Limits: Zero to 160 deg F (Minus 18 to 71 deg C).
i. Thermal Effects: 0.01 percent of full scale per degree F.
j. Warm-up Time: Within 5 seconds.
k. Response Time: 8 ms.
l. Shock and vibration shall not harm the transmitter.

4. Output Signals:

a. Analog Current Signal:

1) Two-wire, 4- to 20-mA dc current source.
2) Signal capable of operating into 1000-ohm load.

b. Analog Voltage Signal:

1) Three wire, zero to 5 V.
2) Minimum Load Resistance: 1000 ohms.

5. Operator Interface:

a. Zero and span adjustments within 10 percent of full span.
b. Potentiometer adjustments located on face of transmitter.

6. Construction:

a. Type 300 stainless-steel enclosure.

b. Swivel fittings for connection to tubing. Fittings on bottom of instrument enclosure.
c. Two 1/2-inch (16-mm) trade size conduit connections isolated from electronics.
d. Screw terminal block for wire connections.
e. Vertical plane mounting.
f. NEMA 250, Type 4X.
g. Mounting Bracket: Appropriate for installation.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a 30lbs force.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.

2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.4 PRESSURE INSTRUMENT INSTALLATION

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support

frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

5. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
6. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Install mounting hardware and gaskets to make sensor installation airtight.
3. Route tubing from the sensor to transmitter.
4. Use compression fittings at terminations.
5. Install sensor in accordance with manufacturer's instructions.
6. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:

1. Locate wall-mounted sensor in an inconspicuous location.
2. Submit sensor location for approval before installation.
3. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
4. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
5. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
6. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 (DN 12) tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet (15 m); otherwise, locate switch in vicinity of system connection.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.6 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.

2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

3.8 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION

SECTION 23 09 23.27

TEMPERATURE INSTRUMENTS

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. Air temperature sensors.
2. Air temperature switches.
3. Air temperature RTD transmitters.

B. Related Requirements:

1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. HART (Highway Addressable Remote Transducer) Protocol: The global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

B. RTD: Resistance temperature detector.

1.4 SUBMITTALS

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

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical

power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: For each exposed product installed in finished space.

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

E. Provide one matching product in Project inventory for each unique size and type.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated [**and cooled**], filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 12.
    b. Indoors, Heated with Filtered Ventilation: Type 1.

c. Indoors, Heated and Air Conditioned: Type 1.

d. Localized Areas Exposed to Washdown: Type 4X.
e. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

   a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
   b. Interchangeable Accuracy: At 32 deg F (zero deg C) within 0.5 deg F (0.3 deg C).
   c. Repeatability: Within 0.5 deg F (0.3 deg C).
   d. Self-Heating: Negligible.

4. Transmitter Requirements:

   a. Transmitter required for each 100-ohm RTD.
   b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F((Minus 45 to 135 deg C).)
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches((450 mm) long).
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2-inch((16-mm) trade size.)

C. Platinum RTD, Air Temperature Averaging Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F((Minus 45 to 135 deg C).)
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
6. Length: As required by application to cover entire cross section of air tunnel.

7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch((16-mm) trade size.)

D. Platinum RTD Outdoor Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F((Minus 45 to 135 deg C).)
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch (16-mm) trade size.

E. Thermal Resistors (Thermistors): Common Requirements:

1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

    a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
    b. Interchangeable Accuracy: At 77 deg F (25 deg C) within 0.5 deg F (0.3 deg C).
    c. Repeatability: Within 0.5 deg F (0.3 deg C).
    d. Drift: Within 0.5 deg F (0.3 deg C) over 10 years.
    e. Self-Heating: Negligible.

4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

F. Thermistor, Single-Point Duct Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F((Minus 45 to 135 deg C).)
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches((450 mm) long).
4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
5. Gasket for attachment to duct or equipment to seal penetration airtight.
6. Conduit Connection: 1/2- inch (16-mm) trade size(.)

G. Thermistor Averaging Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F((Minus 45 to 135 deg C).)
2. Multiple sensors to provide average temperature across entire length of sensor.
3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
5. Length: As required by application to cover entire cross section of air tunnel.

6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch (16-mm) trade size.

H. Thermistor Outdoor Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F((Minus 45 to 135 deg C).)
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Solar Shield: Stainless steel.
4. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
5. Conduit Connection: 1/2-inch (16-mm) trade size.

I. Thermistor Space Air Temperature Sensors:

1. Temperature Range: Minus 50 to 212 deg F((Minus 45 to 100 deg C).)
2. Sensor assembly shall include a temperature sensing element mounted under a flush, brushed-aluminum cover.
3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
4. Concealed wiring connection.

2.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Honeywell International Inc; L482A.
   b. Siemens Building Technologies, Inc; 134-1504.

2. Description:

   a. Two-position control.
   b. Field-adjustable set point.
   c. Manual reset.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

   a. Operating Temperature Range: 15 to 55 deg F (Minus 9 to 13 deg C).
   b. Temperature Differential: 5 deg F (2.8 deg C), non-adjustable and additive.
   c. Enclosure Ambient Temperature: Minus 20 to 140 deg F (Minus 11 to 60 deg C).
   d. Sensing Element Maximum Temperature: 250 deg F (121 deg C).
   e. Voltage: 120-V ac.

f. Current: 16 FLA.
g. Switch Type: Two SPDT snap switches operate on coldest 12-inch (300-mm) section along element length.

4. Construction:

a. Vapor-Filled Sensing Element: Nominal 20 feet (6 m) long.
b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 1/2-inch (16-mm) trade size.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 30 lbs force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.4 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

    a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
    b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

        1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
        2) Do not begin installation without submittal approval of mounting location.

    c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches((1.1 to 1.6 m)) above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches (1500 mm).

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches (610 mm) in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. (1.86 sq. m) and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.6 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.7 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.

B. Provide a complete set of instructional videos covering each product specified and installed and showing the following:

1. Software programming.
2. Calibration and test procedures.
3. Operation and maintenance requirements and procedures.
4. Troubleshooting procedures.

C. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

D. Record videos on DVD disks.

E. Owner shall have right to make additional copies of video for internal use without paying royalties.

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SECTION 23 31 00

DUCTWORK AND HVAC CASINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. This section is intended to replace the following AIA sections:

1. Section 23 3113 "Metal Ducts"
2. Section 23 31 19 "HVAC Casings"

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular metal ducts and fittings.
2. Double-wall rectangular metal ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.
6. Seismic-restraint devices.

B. Related Sections:

1. Section 20 05 93 "Testing, Adjusting, and Balancing for Mechanical and Plumbing" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 23 33 00 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
3. Section 23 35 00 "Special Exhaust Systems" for kitchen, lab, dust collection, mist collection and carbon monoxide/engine exhaust ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints, where necessary or indicated on Drawings, 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" ASCE/SEI 7, and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

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. 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.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports, AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports and AWS D9.1M/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/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.

3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 REFERENCE GUIDES AND INSTRUCTIONS

A. Unless otherwise specified or shown on the drawings, sheet metal construction shall conform to the recommendations of the most recent editions of “HVAC Duct Construction Standards” and the “HVAC Air Duct Leakage Test Manual” published by SMACNA and as augmented by the current “ASHRAE Handbooks” and current NFPA 90A and applicable standards.

B. The sheet metal, unless otherwise shown on the Drawings or specified herein shall be new, hot-dip galvanized, lock forming grade, sheet steel conforming to ASTM A525 and A527 with G90 minimum galvanized coating thickness.

C. The Contractor shall provide all necessary reinforcing, bracing, framing, gasketing and flexible connections as required to prevent vibration transmission, rattling or drumming under all operating conditions of the heating, ventilating and air conditioning systems, whether or not they are specifically called for or detailed on the Drawings. The Contractor shall install all sheet metal clean and free or oil, grease, etc., particularly where insulation adhesive is to be applied. The Contractor shall be responsible for all cleaning required to bring sheet metal to such condition.

D. Contractor’s shop drawings shall show changes in static pressure construction class where maximum velocity levels have been exceeded.

E. All sheet metal ductwork shall be fabricated and installed to form a stiff and rigid construction, free from apparent sag or distortion between hangers. All ductwork shall be cross-broken or beaded, except where insulated with rigid insulation.

F. All sheet metal work exposed to the weather, unless otherwise shown on the Drawings or specified herein, shall not be less than No. 18 U.S. gage galvanized sheet steel with minimum G90 coating thickness.

G. In the event a structural member is located in such a manner as to interfere with the passage of a sheet metal duct and it becomes necessary to enclose the member within the duct, the Contractor shall provide an approved streamlined sheet metal fitting around the member as recommended in SMACNA’s “HVAC Duct Construction Standards” to minimize air turbulence at that point and to increase the size of ductwork to obtain the same velocity.

H. Exhaust ducts from showers shall be aluminum sheet metal alloy 3003-H14, minimum thickness 0.05 inches. Duct reinforcement shall be galvanized steel with bituminous or zinc chromate paint for dielectric isolation or equivalent strength aluminum reinforcement. Ductwork shall be pitched back to exhaust register and shall be constructed so that longitudinal (Pittsburgh lock) seam is at top of duct. Joints shall be soldered or may be sealed with silicone sealant, as approved by Owner. Button punch snaplock seams will not be approved.

I. All outside air intakes or other ducts conveying high moisture content air shall be provided with drains (except for pitched exhaust ducts for showers). Ductwork shall be constructed watertight by welding, soldering or by sealant, as approved by Owner.

J. All ductwork shall be as specified for each pressure class including ductwork located within the truss space of manufacturing buildings, unless otherwise specified herein or shown on Drawings.

2.2 SINGLE-WALL RECTANGULAR METAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL RECTANGULAR METAL DUCTS AND FITTINGS

A. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated. Galvanized coating suitable for application of paint by others.

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-

support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.

F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.

G. Inner Duct: Minimum 0.028-inch (0.7-mm) galvanized solid sheet steel.

H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse 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."

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/A 653M.

1. Galvanized Coating Designation: G90 (Z275).
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) 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 25 and maximum smoke-developed index of 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/A 36M, 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, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches (76 mm), 4 inches (102 mm) or 6 inches (152 mm).
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch w.g. (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
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 65 percent.
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 w.g. (2500 Pa), 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. 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.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch w.g. (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch w.g. (2500-Pa) 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.

2.6 HANGERS AND SUPPORTS

A. See Specification Section 20 05 29 "Hangers, Supports and Expansion Fittings."

2.7 SEISMIC-RESTRAINT DEVICES

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

1. Taylor Devices, Inc.
2. Vibro/Dynamics LLC
3. Bilz Vibration Technology Inc.
4. Or Approved Equal

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California or an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. 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.

D. Restraint Cables: ASTM A 603, galvanized or 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.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

F. 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 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 and flat-oval 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 (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 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."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) 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 (5 m).

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.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" or ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
2. Brace a change of direction longer than 12 feet (3.7 m).

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 prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting."

3.8 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. The following shall be the scope of the new duct leakage testing:

    a. All new duct with a pressure class greater than +2" w.g. and less than 2" w.g.
    b. All duct of any pressure class that will be located in an inaccessible area (e.g. in shafts, above plaster ceilings).
    c. A sampling of approximately 10% of duct constructed to a pressure class greater than -2" w.g and less than +2" w.g. (e.g. duct downstream of supply air terminal units).

        1) If sample passes tests, remaining ductwork of similar pressure class shall be permitted to proceed without further testing.
        2) If sample fails leak test, the sample duct shall be repaired and the leakage test repeated until test passes. Any other duct of similar pressure class that was installed will be repaired in a similar manner.

3. Ducts specified to be tested shall be tested in accordance with the SMACNA Leak Testing procedure. Leaks or imperfections that are detected shall be properly remedied and the tests repeated until all work is reasonably sound.
4. Notify engineer of duct leakage testing schedule. Engineer shall be present at first duct leakage test per system.
5. Air leakage shall not exceed maximum allowable leakage for Seal Class A as defined in SMACNA "HVAC Air Duct Leakage Test Manual," most recent edition.
6. There shall be no audible leaks.
7. A duct system need not be completed before tests are conducted. Sections may be temporarily blanked off or suitably capped, etc., and such sections individually tested as specified. All equipment, portable blower, instruments, temporary connections, blank-offs, etc., necessary to conduct tests as specified shall be provided by the Contractor, and the costs of which shall be included in the Contractor's original bid for the work, without any additional costs to Owner.
8. Ductwork shall be pressure tested to a pressure equal to the specified duct construction pressure (i.e., a duct built to a 3" standard shall be tested to 3").
9. Air measuring stations used for temperature control purposes are not to be used to measure leakage.

3.9 DUCT CLEANING

A. Clean new and existing, if applicable, duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
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.

3.10 START UP

A. Air Balance: Comply with requirements in Section 200593 "Testing, Adjusting, and Balancing for Mechanical and Plumbing."

3.11 METAL DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Underground Ducts: Concrete-encased, galvanized sheet steel, PVC-coated, galvanized sheet steel with thicker coating on duct exterior or stainless steel
2. Ductwork within 20 feet of a shower room exhaust grille, cart wash ductwork, sterilizer ductwork and ducts serving a duct mounted humidifier (2 feet before and 5 feet after humidifier): Type 304 stainless steel.

B. Air leakage shall not exceed maximum allowable leakage for SMACNA Seal Class A as defined in SMACNA "HVAC Air Duct Leakage Test Manual."

C. Supply Ducts:

1. Ducts Connected to Constant-Volume Air-Handling Units:

a. Pressure Class: Positive 3-inch w.g. (750 Pa).

2. Ducts Connected to Variable-Air-Volume Air-Handling Units:

a. Supply duct from AHU discharge to inlet of air terminal units:

1) Pressure Class: Positive 4-inch w.g. (1000 Pa).

b. Supply duct downstream of air terminal units:

1) Pressure Class: Positive 2-inch w.g. (500 Pa).

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 2-inch w.g. (500 Pa).

D. Return Ducts:

1. Return system with air terminal units:

a. Duct from air terminal units to inlet of return fan:

1) Pressure Class: Positive or negative 4-inch w.g. (1000 Pa).

b. Duct from return grille to terminal unit:

1) Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

3. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

E. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

    a. Pressure Class: Negative 3-inch w.g. (750 Pa).

2. Ducts Connected to Air-Handling Units:

    a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

3. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

F. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Pressure Class: Positive or negative 2-inch w.g. (500 Pa).

G. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

2. Stainless-Steel Ducts:

    a. Exposed to Airstream: Match duct material.
    b. Not Exposed to Airstream: Galvanized or match duct material.

3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

H. Liner:

1. Refer to Section 200700 “Thermal Insulation for Mechanical, Plumbing and Fire Suppression” for acoustic duct liners.

I. Double-Wall Duct Interstitial Insulation: Provide with thickness necessary to comply with ASHRAE/IESNA 90.1 tables titled "Minimum Duct Insulation R-Value, Cooling and Heating Only Supply Ducts and Return Ducts" and "Minimum Duct Insulation R-Value, Combined Heating and Cooling Supply Ducts and Return Ducts."

J. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm (5 m/s) 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 (5 to 7.6 m/s):

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm (7.6 m/s) or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

K. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION

SECTION 23 33 00

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.

B. This Section is intended to replace the following AIA Sections:

1. Section 23 33 46 “Flexible Duct”.

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Corridor dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Flexible ducts.

B. Related Requirements:

1. Section 23 37 23 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Section 28 31 11 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.
3. Section 28 31 12 "Zoned (DC-Loop) Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

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 SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Maximum pressure drop through dampers shall be limited to 0.1 inch water column unless otherwise noted or approved by Engineer in writing.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 (Z180) or G90 (Z275).
2. Exposed-Surface Finish: Mill phosphatized.

B. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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

    a. Nailor Industries Inc.
    b. Ruskin Company.
    c. Greenheck Fan Corp.
    d. Or Approved Equal.

2. Standard leakage rating**,** with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Frame: Hat-shaped, 0.094-inch-(2.4-mm-)thick, galvanized sheet steel.
    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 (1.62 mm) thick.

6. Blade Axles: Stainless steel.
7. Bearings:

    a. Oil-impregnated stainless-steel sleeve or Stainless-steel sleeve.
    b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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.

2.4 CONTROL DAMPERS

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

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Ruskin Company.
4. Or Approved Equal.

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. U shaped.
2. 0.094-inch-(2.4-mm-)thick, galvanized sheet steel.
3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 6 inches (152 mm).
2. Opposed-blade design.
3. Galvanized-steel
4. 0.0747-inch-(1.9-mm-) thick dual skin.
5. Blade Edging: Closed-cell neoprene.

E. Blade Axles: 1/2-inch-(13-mm-) diameter; stainless 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 (minus 40 to plus 93 deg C).

F. Bearings:

1. Oil-impregnated stainless-steel sleeve or Stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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.

2.5 FIRE DAMPERS

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

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Ruskin Company.
4. Air Balance Inc.
5. Or Approved Equal.

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000-fpm (10-m/s) velocity.

D. Fire Rating: 1-1/2.

E. Frame: Curtain type with blades inside airstream; fabricated with roll-formed, 0.034-inch-(0.85-mm-)thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness:, 0.138 inch (3.5 mm), or 0.39 inch (9.9 mm) 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.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch-(0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-(0.85-mm-) thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

2.6 FLANGE CONNECTORS

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

1. Ductmate Industries, Inc; Ductmate 25/35/45 Rectangular Flange System.
2. Rolastar TDF
3. Or Approved Equal.

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.

2.7 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Double wall.

2.8 DUCT-MOUNTED ACCESS DOORS

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

1. Ductmate Industries, Inc;.
2. Greenheck Fan Corporation.
3. Ruskin Co.
4. Or Approved Equal.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures (7-2) 7-2M, "Duct Access Doors and Panels," and 7-3, "Access Doors - 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 (25-by-25-mm) 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 (300 mm) Square: No hinges and two sash locks.
    b. Access Doors up to 18 Inches (460 mm) Square: Continuous and two sash locks.
    c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Continuous and two 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. Factory set at 3.0- to 8.0-inch wg (800 to 2000 Pa).
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch-(25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.9 FLEXIBLE CONNECTORS

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

1. Federal Mogul Thermaflex.
2. Flexmaster USA.
3. Or Approved Equal.Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

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 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch-(70-mm-)wide, 0.028-inch-(0.7-mm-)thick, galvanized sheet steel or 0.032-inch-(0.8-mm-)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. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

2.10 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. Flexaust Co.
3. Or Approved Equal.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1

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 (75 through 460 mm), to suit duct size.

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 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 backdraft and 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.

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 dampers according to UL listing.

H. Install duct security bars. Construct duct security bars from 0.164-inch (4.18-mm) steel sleeve, continuously welded at all joints and 1/2-inch-(13-mm-)diameter steel bars, 6 inches (150 mm) o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch (63-by-63-by-6-mm) steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch (300-by-300-mm) hinged access panel with cam lock in duct in each side of sleeve.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.

2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot (15-m) spacing.
8. Upstream from turning vanes.
9. Control devices requiring inspection.
10. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

L. Label access doors according to Division 23 Section 200553 "Identification for Plumbing, HVAC and Fire Suppression Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect diffusers to ducts with maximum 72-inch lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with liquid adhesive plus tape or adhesive plus sheet metal screws.

Q. Install duct test holes where required for testing and balancing purposes.

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

SECTION 23 34 00

HVAC FANS

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. This Section is intended to replace the following AIA Sections:

1. Section 23 34 13 “Axial HVAC Fans”
2. Section 23 34 16 “Centrifugal HVAC Fans”
3. Section 23 34 23 “HVAC Power Ventilators”

1.2 SUMMARY

A. Section Includes: For each product.

1. Centrifugal roof ventilators.
2. Axial roof ventilators.
3. Upblast propeller roof exhaust fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data:

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators
7. Fan speed controllers.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Operation and Maintenance Data: For HVAC fans 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, 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: HVAC fans shall comply with UL 705. HVAC fans for use for restaurant kitchen exhaust shall also comply with UL 762.

1.6 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 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

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. Capacities and Characteristics: Refer to drawings.

1. See Schedule on Drawings.

2.2 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. Greenheck Fan
2. Acme Fan
3. Loren Cook Company
4. Aerovent
5. Twin City Fan & Blower
6. Or Approved Equal

B. Housing: Removable, galvanized steel, mushroom-domed top; 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.
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 (13-mm) 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. See Section 07 72 00 “Roof Accessories.”

G. Capacities and Characteristics: Refer to drawings.

1. See Schedule on Drawings.

2.3 UPBLAST PROPELLER ROOF EXHAUST 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. Greenheck Fan
2. Acme Fan
3. Loren Cook Company
4. Aerovent
5. Twin City Fan & Blower
6. Or Approved Equal

B. Wind Band, Fan Housing, and Base: Reinforced and braced galvanized steel, containing galvanized-steel butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

1. Damper Rods: Steel with bronze bearings.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheel: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Weatherproof housing of same material as fan housing.
3. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
4. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
5. Pulleys: Cast-iron, adjustable-pitch motor pulley.
6. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.

E. Roof Curbs: See Section 07 72 00 “Roof Accessories.”

F. Capacities and Characteristics: Refer to drawings.

1. See Schedule on Drawings.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 20 05 13 "Common Motor Requirements for Mechanical, Plumbing and Fire Suppression.

2.5 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with 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. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 20 05 48 "Noise, Vibration and Seismic Controls for Mechanical, Plumbing and Fire Suppression.

E. Unit Support: Install centrifugal fans level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

F. Install units with clearances for service and maintenance.

G. Label fans according to requirements specified in Section 20 05 53 "Identification for Plumbing, HVAC and Fire Suppression 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 fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 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 test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. 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. See Section 200593 "Testing, Adjusting, and Balancing for Mechanical and Plumbing" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 DEMONSTRATION

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

END OF SECTION

SECTION 23 35 00

SPECIAL EXHAUST 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. Carbon monoxide ductwork.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for dust collection ducts.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment 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. Detail fabrication and assembly of hangers and seismic restraints.

C. Submit for each exhaust stack, flue, chimney, or vent, suggested reinforcement of building structure, other support requirements, wire or structural steel guy configuration, stack support loads, guy loads on guy anchors, and stack flashing and seal.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

a. THRTHRTHRT

1.5 QUALITY ASSURANCE

A. Reference Standards

1. Standards of SMACNA:

a. HVAC Duct Construction Standards (DCS), Second Edition, 1995.
b. Rectangular Industrial Duct Construction Standards.
c. Round Industrial Duct Construction Standards.
d. Manager's Guide for Welding.
e. Testing, Balancing and Adjusting of Environmental Systems.

2. NFPA 90A, Air Conditioning & Ventilating Systems.
3. NFPA 91, Blower & Exhaust Systems.
4. NFPA 96, Vapor Removal from Commercial Cooking Equipment.
5. ACCA, Air Conditioning Contractor's Association
6. ACPA, American Concrete Pipe Association.
7. ACGIH "Manual of Recommended Practice for Industrial Ventilation".
8. ADC, Air Diffusing Council.
9. ASHRAE Fundamentals Handbook and Product Directory.
10. AISI, American Iron and Steel Institute.
11. ANSI, American National Standards Institute.
12. API, American Petroleum Institute.
13. ASTM, American Society for Testing and Materials.
14. AWS, American Welding Society.
15. FS, Federal Specifications.
16. NBS, National Bureau of Standards
17. Wherever the words "should", "recommended', "it is recommended', "preferred' or "must" appear in the text of the referenced standards, interpret them as the word "shall', to indicate mandatory conformance. Where the words "can" and "may" are similarly used in conjunction with an option which would result in superior quality or strength construction, interpret them as "shall'.

B. Fire Dampers, Ceiling Dampers And Heat Stops

1. Fire dampers and ceiling dampers shall have a UL or equivalent label or be manufactured and labeled in accordance with SMACNA’s fire damper labeling service.

C. Requirements of Regulatory Agencies

PART 2 - PRODUCTS

2.1 DUCTWORK SPECIALTIES

A. Refer to Section 23 33 00 "Air Duct Accessories" for additional ductwork specialty information and specifications.

B. Flexible Connectors For High Temperature Use

1. Fabric: UL listed and conforming to NFPA 90A, 16 ounce, waterproof and noncombustible, air tight, glass fabric, coated with fire retardant silicone rubber. Minimum clear width, not including clamping section shall be 6 inches.

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

1) Ventfabrics, Inc., "Ventsil".

C. Duct Probe Access

1. Duct probe access: Provide plugs with threaded or twist on cap fittings.
2. Duct probe access fittings will be provided as part of the Work under another Contract.

D. Manual Dampers (Heavy Duty)

1. Manual dampers (high pressure industrial): Multiblade type with opposed blades for control service. Fabricate of mill galvanized carbon steel, two coat baked enamel painted carbon steel. Damper maximum leakage of 2% of total fan volume at shutoff. Construction and assembly shall be such that no noise producing blade vibration occurs at velocities 20% greater than maximum system design velocity. Linkage shall be capable of withstanding loads equal to two times maximum operating force that may be exerted by the operator provided without deformation.

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

1) EFFOX, Inc.
2) Ron Noc Ind. Inc.
3) Mosser Damper Co., Allentown, Pa.

E. Pressure Relief Damper

1. Pressure relief damper: Counterbalanced or spring loaded damper with blades linked together to open at indicated preset pressure.

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

1) American Warming and Ventilating Co.

2) Ruskin Mfg. Co.

F. Flanged Connection

1. Manufactured flanged duct connection

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

1) Ductmate.
2) TDF.
3) Approved equal.

2. Breakaway connection, metal or plastic cleats

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

1) Ruskin.
2) Approved equal.

G. Fire Barrier Blanket

1. Provide UL listed 2-hour non-combustible fire blanket with provisions for access to duct access doors for duct cleaning. Blanket shall be lightweight, flexible with no requirement for attachment to duct and no dangerous off-gassing before or during fire exposure.

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

1) Fire Master FP-60.
2) Vesuvius, "Pyroscat FP".

2.2 SEALING MATERIAL

A. All sealing material shall be approved by the Plant Engineer before being used.

B. Companion flanges shall be wiped clean of oil and sealed by an application of the following products

1. Dow Corning "DAP 100% Silicone Sealant 8646" Ford TOX No. 048357
2. Dow Corning "735 Oil Resistant Sealant" Ford TOX No. 138437
3. GE "RTV108 Silicone Rubber Sealant" Ford TOX No. 015019
4. Loctite "5900 Flange Sealant RTV" Ford TOX No. 135127

C. The bead of sealant shall not be distorted or smeared while aligning the companion flanges except for the motion of the uniform compression of the bead by the flanges being pulled together. If lateral distortion or smearing occurs reapply the bead and start over.

D. Sealant pattern shall be circle the flange and each bolt hole

2.3 ALTERNATE SEALING METHOD

A. Gaskets for flanged joints in mist control systems shall be Gore-Tex gasket tape, pure virgin polytetrafluoroethylene (PTFE) in expanded form, available from:

1. W.L. Gore and Associates, Inc.

B. Gasket width shall be as follows:

	Duct Diameter	Sealing Width* (Inches)	Gasket Width (Inches)
2.	4 thru 28	7/16 thru 5/8	1/4
3.	29 thru 48	3/4 thru 1	3/8

a. *Sealing Width Distance from inside face of flange angle to inside face of bolthole.

C. Gasket pattern shall be installed per the manufacturer's pattern and recommendations. Care must be exercised to compress the gasket uniformly.

2.4 FUME EXHAUST STACK AND BREECHING

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

1. Airtek Corp.
2. Van Packer Corp.

B. Fume exhaust stack and breeching: Provide breeching and cantilevered stack constructed for wind velocities up to 100 MPH from any direction. Provide stack flashing welded to stack and extending over roof curb. Provide weather seal

C. Construct from black carbon steel sheet per ASTM A 570 Grade C and structural steel elements per ASTM A 36.

D. Coat breeching, stack and stackhead interiors per manufacturer's instructions. Exterior painting shall be done as part of the WORK under SECTION 09 90 0. Interior coating manufacture:

1. Heresite Saekaphen, Inc.
2. Wisconsin Protective Coating Corp. Plasite 7122.

E. Fabricate stackhead substantially as indicated on Fig. 6 -24 for vertical discharge stacks in ACGIH "Manual of Recommended Practice for Industrial Ventilation".

F. Provide stack with indicated sampling facilities.

2.5 OVERHEAD CARBON MONOXIDE EXHAUST SYSTEM

A. Consist of ductwork, flexible connections, fan, hose, fittings, cables, winches, lifting straps and pulleys as specified herein.

B. Ductwork and fittings: Sheet metal-galvanized spiral.

C. Fan: Refer to Section 23 34 00 "HVAC Fans" for requirements.

D. Individual drops: Consist of indicated lengths of 6 inch neoprene flexible hose with flange adapters and stack adapters. Provide lifting straps, pulleys, hooks, winch and 100 feet of vinyl coated galvanized steel cable for each station. Construct tail pipe adapters to permit insertion of engine exhaust analyzing probes.

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

    a. Monoxivent Systems, Inc.
    b. Car Mon Products, Inc.
    c. Engwald Corp.

2.6 ENGINE EXHAUST SYSTEM (EES)

A. General Requirements

1. Breeching, ductwork, piping and accessories:

    a. Breeching, ductwork, piping and accessories shall include, but not necessarily be limited to, the following:
    b. Ducts, plenum chambers, transitions and casings
    c. Support hangers, angle stiffeners and necessary bracing
    d. Explosion/pressure relief devices
    e. Access and/or inspection doors and duct test holes
    f. Expansion joints
    g. Gaskets and flanges
    h. Ductwork suitable for the EES maximum positive/negative pressure range.
    i. Accommodations for instrumentation and controls, and sampling

2. All breeching, ducts, piping, plenums, and housings shall be constructed in a neat, strong, and substantial manner with smooth interior and exterior surfaces, and essentially airtight.

    a. Ducts shall be reinforced with external structural members to assure rigidity.

3. All ductwork shall provide for expansion and contraction and be anchored such that work will not be distorted nor fastenings seriously stressed from expansion and contraction of the metal.

4. Radius and transition type elbows and offsets, unless otherwise detailed on the drawings, shall be made with a minimum centerline radius of 1-1/2 times the duct width in the turning plane
5. Provide weather shields for all weather exposed instruments specified herein or in other Sections
6. Locate all instruments to provide access for maintenance.

B. Engine Exhaust Pipe Installed Below And Above Roof

1. Engine exhaust pipe below and above roof before connecting to the double wall ductwork above the roof shall be Type 304L stainless steel pipe per ANSI B36.19, Schedule 10, with butt welded fittings per ASTM A774, ANSI B16.9, ANSI B36.19, and slip on flanges, Class 150, per ANSI B16.5. Flanges at equipment connections shall be 304L ss, drilled for 125/150 lb hole spacing.
2. Ductwork shall be electrically conductive and grounded to prevent static discharge. Jumpers shall be provided across flanged connections to assure electrical continuity and conductivity.
3. All steel shapes welded to ductwork shall be type 304L SS.
4. Welding electrodes shall be compatible with base material.
5. Bolts for erection and connections shall conform to ASTM A307-90.
6. Type ERV-1 spring loaded explosion relief vents shall be provided for locations on the Sch 10, 316 SS engine exhaust pipe where indicated on the drawings.

C. Engine Exhaust Ductwork Installed Above Roof

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

    a. Selkirk Metalbestos Models IPS C1 and C4, or as indicated in the drawings.
    b. Or Approved Equal

2. All engine exhaust pipe for the racing engine exhaust shall be Sch 10, 304L stainless steel as specified for engine exhaust pipe installed above roof.
3. Engine exhaust ductwork installed above roof: Duct and Fittings: Duct and fittings shall be a standard manufactured double walled insulated duct system with insulation thickness as shown on the DRAWINGS. Duct and fittings shall consist of an inner duct wrapped with ceramic fiber insulation and an outer jacket. The inner duct shall be 316SS 0.035" for 36" dia. and smaller, 0.048" for larger than 36" dia. The outer jacket shall be 316SS 0.025" for 24" dia. and smaller, 0.034" for larger than 24" dia. The exhaust duct system shall consist of standard lengths of straight pipe not to exceed 36 inches long or less if required to provide adequate stiffness to preclude collapse under the specified operating pressure range, lined bellows joint expansion fittings, adjustable length sections, elbows, drain fittings, tees, inner duct and outer jacket connection bands, high temperature sealant, support/guide rings, plate supports, explosion relief valves and combination explosion relief and access panels.
4. Duct and fittings shall be pressure tight up to 60" w.c. design pressure and be certified as rated for a plus/minus 30" w.c. operating pressure.
5. Double wall duct shall be UL listed for applications up to 1,400 deg F under continuous operating conditions and comply with NFPA.

6. Inner duct shall be electrically conductive and grounded to prevent static discharge. Lugs shall be provided at each inner pipe connection to assure electrical continuity and conductivity.
7. The inner duct joints shall be sealed by use of overlapping type Vee Bands with premixed 2,000 deg F sealant. The outer channel bands shall be sealed with a premixed 600 deg F sealant. Slip joints are not acceptable, except where adjustable sections are provided for length adjustment.
8. Expansion joints shall be lined corrugated type. Slip type expansion joints are not acceptable. Expansion joints shall compensate for all engine exhaust gas temperature induced thermal expansion.
9. Special factory fabricated fittings shall be provided as required to suit the duct and drain system design. Duct manufacturer shall be responsible for the design reinforcement of the 90 degree tee fitting, if required, for explosion relief vent installation.
10. Ductwork and structural steel support framework shall be configured to allow a person to walk under the ductwork at roof stair locations. Styles over ductwork are not acceptable.

D. Engine Exhaust Ductwork (Piping) Fabrication

1. Continuous butt or fillet welds shall be used where required to make ductwork airtight except as otherwise noted on the drawings or elsewhere in this specification.
2. Overall dimensions per drawings are approximate. Actual dimensions shall be verified on shop drawings and upon completion of fabricating. These dimensions shall be within the tolerances required by the governing standard or code.
3. When fabrication is completed, all surfaces shall be cleaned of all dirt, debris, mill scale, rust, weld spatter, oil and grease; ready for inspecting
4. Provide 14 gauge galvanized steel bird screens at air inlets.
5. Ductwork, unless otherwise specified for specific applications, shall conform to SMACNA Industrial Duct Construction Standards; ACGIH Industrial Ventilation; American Welding Society or ASME; MSS SP-58 and SP-59 and AISC for support related work.
6. Test cell engine exhaust connections (hard pipe to flex) shall have Aeroquip/Marman couplings.

E. Expansion Joints

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

    a. PEBCO/MIPCO
    b. Or Approved Equal

2. Expansion joints for Sch 10, 304L SS duct (piping) shall be 125/150 lb flanged multiple ply low spring rate stainless steel bellows expansion joint for service at temperatures encountered. System pressure design shall be plus/minus 30 inches w.c. Bellows shall be designed in accordance with Expansion Joint Manufacturers Association standards. All welding shall be in accordance with ASME Section IX. Provide not less than 20 convolutions with internal liner, with drain holes for vertical installations, and external cover. Provide: AISI Type 321 stainless steel for service temperatures through 1450 deg.

F. Axial compression and/or lateral offset movements and forces shall be noted on shop drawings submitted for Engineer's approval.

F. Gaskets

1. Gaskets shall be selected to accommodate the plus/minus 60 inch H2O pressure, the 750 Deg F upset condition, and the gas constituents listed.
2. Gaskets for Sch 10 pipe and flanged connections to the double wall insulated duct shall be corrugated metal strip 316 stainless steel spirally wound with Flexicarb flexible graphite filler, carbon steel outer compression limiting and centering ring, and 316 stainless inside compression ring; Flexitalic Style CGI or equal. Gaskets shall conform to API Specification 601.

G. Engine Exhaust Insulation

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

    a. Rockwool Manufacturing Co. (205.699.6121) Delta- FPF 10 Pre-Form
    b. Rockwool Manufacturing Co. (205.699.6121) Delta- PC 10 Block Precision Cut Easy Wrap Roll Form
    c. Or Approved Equal

2. Provide asbestos-free, non-combustible materials, rated per NFPA STD-90A, NFPA STD 255 and ASTM E 84, with Flame Spread Index (FSI) of 25 and Smoke Developed Index (SDI) of 50 or less, except as otherwise specified.
3. Engine Exhaust Service Below Roof: 4" Thickness 350 To 1200 Deg F Maximum Continuous Duty Rigid Mineral Wool Board or Pipe Segments, 1200 Deg F rated, with molded or precision cut fabricated pipe barrel/fittings; ASTM C612 /non-corrosive to stainless steel, not less than 10 or 12 lbs/cf density; 100 psi at 5% deflection cold compressive strength. Provide two layers where total insulation thickness is greater than 2". Cover with aluminum jacket.
4. Engine Exhaust Service above Roof: Fiberglass insulation covered with aluminum jacket.
5. Provide removable insulation jacketing on the required portions of the Fike diverter housings. Material selection to match that installed for Test Wings 1 and 2.

    a. Contact Mike O'Connell, Michigan Mechanical Insulation, Inc. 800-478-7505.

6. Aluminum Jacket: 16 mil AND 24 mil, thickness. Mil thickness sheet shall be not less than 36" long with minimum 3-inch lap at 10 and 2 o'clock; 3/4" wide banding on 9" centers; 4 o'clock longitudinal laps.

H. Insulated Anchors

1. Design, engineer, fabricate and deliver supports from ASTM A-36 carbon steel structural elements using stainless steel poison-pads to interface with duct/pipe surface alloys, insulation shall create a thermal break, shall be chlorides free, completely weather protected against wetting by ambient conditions. Jacket with 32 mill Childers or equal aluminum jacketing. Carbon steel shall be factory prime painted.

I. Engine Exhaust Fans

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

    a. New York Blower
    b. MAS Air Systems
    c. Or Approved Equal

2. The fan shall be an AMCA Class IV, AMCA Type C Spark resistant construction, Arrangement No.1, single inlet, single width, flanged connections, heavy duty, industrial centrifugal scroll type with wheel flange and back plate, elevated temperature design with heat slinger shaft seal, and high temperature grease, factory insulated and metal jacketed for weather exposed thermal and noise control service. Provide Type 316 stainless steel shaft, ceramic felt penetration seal. Bearings shall be grease lubricated pillow block type, not requiring cooling water and AFBMA L- 10 (not average) rated for 150,000 hours under duty conditions. Vibration at fan bearings shall not exceed 2.0 mils peak-to-peak over duty range. Unit shall be suitable for 24 hour/day operation at normal operating temperatures ranging to 550 Deg F.
3. Fan wheel blade design shall be backwardly curved for high efficiency and have non overloading performance characteristics. Blades shall be continuously welded to inlet cone and back plate. Wheels shall be statically and dynamically balanced.
4. Fan wetted weld jointed surface materials shall be Type 316L stainless steel.
5. Belt drive: V-belts shall have not less than a 2.0 service factor. Sheaves shall be dynamically balanced; belts matched; and drive shall be weather/OSHA guarded and color coded
6. Fit fan with unitary structural steel base, drain coupling, OSHA drive guard, access door, heavy duty Teflon impregnated woven fiberglass cloth high temperature flexible connectors.
7. Provide fans with duty point selection on a performance curve sloped such that no instability of delivery could occur over an output operating change, ranging from design duty point volume to nominal 33 % of duty point volume at the reduced speed, and essentially no operating pressure change ranging from design duty point volume to nominal 33% of duty point volume.
8. Fan sound power spectrum shall be a relatively smooth curve without peak disturbances. the four principal orthogonal surfaces of the fan, shall not exceed 80 dBA.
9. Fan motor shall TEFC, certified "Quiet" type and shall comply with specified standards, to the degree applicable except that motor shall be a premium, high efficiency type with Class H insulation, specifically suitable for adjustable frequency speed control without overheating. Furnish motors conforming to the requirements of NEMA MG1, Part 31, Definite Purpose Inverter-Fed Motors.
10. Adjustable Frequency Controllers (AFC): The variable speed drive system is furnished as part of the Work Specified under 26 Series Sections.
11. Vibration Isolation: Refer to Division 23 Section "Vibration Control" for requirements.
12. Provide acoustical/thermal insulation to limit the surface temperature to 140 deg F and the radiated sound pressure level to 80 dBA at 5 feet from the unit.

J. Electric Motors

1. Motors located outdoors shall be provided with space heaters for protection against the condensation of moisture.
2. Exhaust Fan Motor

    a. The exhaust fan shall be directly coupled to an industrial rated TEFC GM 7E-TA Motor. The motor shall be selected with 20% spare capability over the system requirements at design speed.
    b. HP minimum = (BHP at full design volume and at design system pressure x safety factor) x 1.20
    c. Motor shall be single voltage 460 VAC, 3 Phase, 60 Hz, totally enclosed, fan cooled, ball bearing (TEFCBB), per OWNER'S Standards, with 2.0 service factor V-belt power transmission.
    d. The VFD and motor must also be able to support the fan at full motor speed assuming the system pressure increases as the square of the volume change and the horsepower as the cube of the volume change.
    e. System static = design system head x safety factor x (alternate vol/design vol)2
    f. The motor will be rated and selected for compatibility with the Variable Frequency Drive (VFD) for operation at nominal 1550 RPM, with speed turn-down of 4:1, and maximum up to 1780 RPM.
    g. Fan motor shall be provided with a fusible, flange mounted disconnect switch.
    h. Motors controlled by variable frequency drives (VFDs) shall include an Aegis or Inpro-Seal shaft grounding ring or similar in the assembly. Motors greater than 100 hp shall include insulated ceramic bearings on the opposite shaft end and double grounding rings on the shaft end. The double grounding rings shall include a shaft grounding ring and an external grounding ring. Bond a jumper from motor base to a welded nut on the fan base and bond jumper from fan base to ground field to reduce the effects of circulating currents.

2.7 BALANCING DAMPERS

A. Blast gates shall be used for balancing of the special exhaust systems.

B. Blast gates dampers shall have a bolt-style locking device.

C. Blast gates shall be installed in accessible locations with the blade entering the top of a horizontal duct or angled up on vertical ducts to reduce the potential for blade leakage.

D. Blast gates shall be "full" type, fabricated of 14 gauge galvanized steel body with 12 gauge blade, as manufactured by Kirk & Blum, with companion flanges welded on both ends.

E. Blast gate material shall match the duct material unless otherwise noted on the drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 DUCT SCHEDULE

A. Overhead Carbon Monoxide Exhaust System shall be one of the following:

1. Galvanized sheet metal ductwork, 6" WG negative, Seal Class A, per SMACNA HVAC Duct Construction Standards, Round Industrial Duct Constructions Standards or Rectangular Industrial Duct Constructions Standards.
2. Black carbon steel sheet metal ductwork, 6" WG negative, Seal Class A, per SMACNA HVAC Duct Construction Standards, Round Industrial Duct Constructions Standards or Rectangular Industrial Duct Constructions Standards.
3. Coated carbon steel pipe or light weight stainless steel pipe, welded construction except flanged for connection to equipment.
4. Stainless steel sheet metal ductwork, 2" WG negative, Seal Class A, per SMACNA HVAC Duct Construction Standards, Round Industrial Duct Constructions Standards or Rectangular Industrial Duct Constructions Standards.

3.3 DUCTWORK FABRICATION

A. Fabricate sheet metal construction per "Referenced Standards", except as modified and supplemented by this specification.

B. Fabricate ductwork to prevent failure under pressure or vacuum created by fast closure of ductwork devices. Provide leaktight automatic relief devices where indicated.

C. Fabricate necessary offsets and transformations to avoid interference with the building construction, piping, or equipment. Make easements (streamliners) for duct obstructions per SMACNA (HVAC Duct Construction Standards)(Round Industrial Duct Constructions Standards)(Rectangular Industrial Duct Constructions Standards).

D. Where ducts pass through walls and floors, finish wall openings with metal trim strips, and curb floor openings where indicated. Use metal sleeves; wood frames are not permitted.

E. Where ducts pass through fire rated walls and floors, or walls and floors of buildings more than two stories high, fill voids and cavities around wall and floor penetrations with firestopping and smoke sealing materials to maintain the required fire rated condition of substrate.

F. Duct dimensions on Drawings are interior dimensions. Dimensions shall be increased as necessary to compensate for liner thickness.

G. Where rectangular sheet metal ductwork is indicated, on approval by the Architect/Engineer, equivalent capacity round ductwork may be substituted.

H. Ducts exhausting shower rooms shall be aluminum sheet metal soldered watertight and pitched to the shower bathroom registers.

I. Outside air intake ducts and housings shall be sheet metal, soldered watertight and provided with drains where indicated.

J. Outdoor ductwork shall be sheet metal and soldered watertight.

K. Repair galvanized surfaces damaged by method of duct fabrication by the application of zinc rich paint per manufacturer's instructions.

L. Enclose dampers located behind architectural intake or exhaust louvers in a sheet metal collar and seal to building construction

M. Crossbreak or bead rectangular sheet metal ducts, 19 inches wide or larger, which have more than 10 square feet of unbraced panel (including externally insulated ducts). Where sheet metal is not crossbroken or beaded, increase sheet metal gage by four gage numbers, i.e., 24 gage crossbroken equal to 20 gage not crossbroken.

N. Where ducts pass through fire walls or floor dividing conditioned spaces from unconditioned spaces, provide a flanged duct segment for installation during the time of wall construction, to provide a tight, hermetic seal.

O. Round Duct Requirements

1. Provide duct, fittings, joints and reinforcement per SMACNA HVAC Duct Construction Standards for pressures up to 2" WG positive or negative. For pressures greater than 2" WG negative fabricate per SMACNA Round Industrial Duct Construction Standards. Round duct connections to main shall be:

    a. 45 degree lateral.
    b. Combination tee.
    c. 2-way "Y".
    d. Conical tee.

3.4 DUCT AND EQUIPMENT SUPPORT SYSTEM INSTALLATION

A. General

1. Select and provide duct and equipment support system per SMACNA (HVAC Duct Construction Standards)(Round Industrial Duct Constructions Standards)(Rectangular

Industrial Duct Constructions Standards). After system start up, replace or otherwise alleviate condition of any duct support element which vibrates.

2. Attach hot rolled carbon steel, prime coated hanger rods, angles, and straps to beam clamps, concrete inserts, and masonry anchors and fasteners per SMACNA (HVAC Duct Construction Standards)(Round Industrial Duct Constructions Standards)(Rectangular Industrial Duct Constructions Standards). Set inserts and anchors in conjunction with other Trades. Lugs welded to ducts are not acceptable as sole supports. Powder actuated fasteners into steel or concrete, welded studs, C clamps, and friction clamps are not acceptable.
3. Do not hang ductwork or equipment from roof deck, piping, other ducts or equipment.
4. Provide not less than one set of two vertical support elements for each point of support and each length of duct. Install supports on sides of duct turns, branch fittings and transitions. Cross brace hangers vertically and laterally to eliminate sway.
5. Support rectangular ducts in sizes to 36 inches by strap type hangers attached at not less than three places to not less than two duct surfaces in different planes or by trapeze hangers. Perforated strap hangers are not acceptable. Support rectangular ducting 36 inches and larger with trapeze hangers.
6. Use angle iron "V" construction supports or similarly rigid construction for vertical ducting which needs lateral support. Anchor downcomers to building to prevent swaying due to functional operation of any discharge grille directional device. Where no building element is convenient, multi point cables, structural elements or angle iron may be used.
7. Where ducts are required to have insulation with a vapor sealed facing, support duct on trapeze hangers. Space hangers far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside of the trapeze. Under no circumstances shall duct hangers penetrate the vapor sealed facing.
8. Where ductwork system contains heavy equipment, excluding air diffusion devices and single leaf dampers, hang such equipment independently of the ductwork with rods or angles sized to support the load.
9. Duct hangers in direct contact with galvanized duct surfaces shall be galvanized steel or black carbon steel painted with zinc rich paint.
10. Allowable loads on purlins or the top chord of jack trusses between panel points shall be such as to produce a moment no greater than the moment produced by a one kip concentrated load at midspan of the purlin or jack truss or by the uniform mechanical (utility) load specified on the DRAWINGS. Loads shall not be supported from the top chord of roof or carrying trusses except at their panel points.
11. When the hanger load exceeds the above limits, provide reinforcing of purlin(s) or additional support beam(s). When an additional beam is used, install beam such that it frames into the roof purlin or jack truss top chord or bears on the roof truss top chord panel point.
12. Limit the location of supporting elements for ductwork and equipment when supported from roof to panel points of the bar joists and limit the allowable load on the bar joist such that the loads produce a moment no greater than the moment produced by one kip load at mid span of bar joist or by a uniform (utility) load specified on the Drawings.
13. When the hanger load exceeds the above limits, provide reinforcing of the roof bar joists or additional structural support as required. When an additional member is used, support the added member at the panel points. Stabilize member by connection to adjacent roof bar joists.

14. Consider bar joists used for supporting fire protection sprinkler mains, electrical lighting fixtures, electrical power duct or cable tray as fully loaded. Supplemental reinforcing of these bar joists or auxiliary support steel shall be furnished and installed by the Contractor.
15. Building structure shall not be reinforced except as approved by the Architect/Engineer in writing.
16. Use approved cast in place inserts or built in anchors for attachment to concrete structure. Size inserts and anchors for the total applied load with a safety factor per applicable codes but in no case less than 5. Coordinate installation of all imbedded items with the WORK under other SECTIONS. Installed imbedded items per manufacturer's instructions. Position anchorage and imbedded items as indicated and support against displacement during placing of concrete. Cutting or repositioning of concrete beam or girder to accommodate inserts will not be allowed. Provide removable closures in imbedded device openings to prevent entry of concrete.
17. Support piping and equipment from concrete building frame, not from roof or floor slabs unless otherwise indicated.
18. Use cast in place inserts in concrete beams and girders. Masonry and other drilled anchors will not be permitted. Use wedge type inserts on vertical surfaces only.
19. Attach duct supports to the side of concrete joists. Provide supplementary support steel as required. Cast in place or drilled anchors will not be permitted in the bottom of concrete joists.
20. Each insert shall be capable of supporting one kip unless otherwise indicated.
21. Where attachment by cast in place inserts is not possible, specified or approved masonry anchor devices may be used after submission of test criteria and receipt of written approval by the ARCHITECT ENGINEER.
22. Allowable loads on precast prestressed concrete floor slabs shall not exceed recommendations of manufacturer. Ductwork and specialties shall be supported wherever possible by means of 14 gage galvanized hanger straps installed in grouted joints between adjacent concrete slabs. Holes, not requiring cutting of prestress strand, shall be core drilled in hollow sections of slabs only in accordance with the manufacturer's standard recommendations. No drilling or cutting of prestress strand portion of slabs will be permitted.

3.5 GENERAL SPECIALTY EXHAUST INSTALLATION

A. Coordinate firestopping where ducts penetrate fire separations with requirements in Section 07 84 13 "Penetration Firestopping."

B. Install airtight maintenance access doors where indicated.

C. Connections: Make duct connections according to the International Mechanical Code.

D. Support ducts at intervals recommended by manufacturer to support weight of ducts and accessories, without applying loading on equipment.

1. Securely attach supports and bracing to structure.
2. Hangers are only allowed to be hung from building steel or intermediate steel provided by this Contractor.

3. Hanging from other mechanical or electrical systems is prohibited.

E. Design the supports for horizontal oil mist ductwork with the assumption that the duct is 1/3 full of water (from the fire suppression system sprinkler system).

3.6 ENGINE EXHAUST SYSTEM INSTALLATION

A. General Requirements

1. The work of the Contract Documents, as related to the providing of 316 stainless steel piping and a standard manufactured insulated double wall stainless steel ductwork system in accordance with the requirements of this Section, is intended to be executed by professional/skilled trades, certified and experienced in welding of stainless steel and other alloys for high temperature systems, in accordance with best trade practices and applicable standards, manufacturers installation instructions and criteria of the SMACNA Round Industrial Duct Construction Standards, AISC for stainless steel and carbon steel fabrication, ASME Unfired Pressure Vessel Code Section IX and or AWS certified and procedure qualified welders and therefore, skilled trade stainless steel and carbon steel fabrication and welding procedures/details/practices/minutia are not itemized herein. Weld all stainless steel engine exhaust piping under inert gas purge at 15 scfh. Do not use carbon steel contaminated tools/equipment to fabricate stainless steel piping. The Bidder, by submitting a bid for this work, automatically represents itself as qualified as specified.
2. Install accessory materials in strict accordance with manufacturer’s recommendations.

B. Inspection

1. Inspect ductwork installation to make sure that ducts are permanently installed with all hangers and supports in place.
2. Inspect surfaces to be insulated for freedom from loose rust and mill scale, oil, dirt and other foreign materials.
3. Check that all ducts have been tested and approved.
4. Report all deficiencies in the ductwork system to the Engineer for correction.

C. Engine Exhaust Pipe Installed Above and Above Roof

1. All engine exhaust duct (piping) shall be installed by a certified welder for process piping systems
2. All exhaust duct (piping) supports and hangers shall be as specified in Section 200529 "Hangers, Supports and Expansion Fittings for Mechanical, Plumbing and Fire Suppression." Duct/piping is subject to extreme temperature cycling (ambient to 750 deg F) resulting in elongation and contraction. Supporting elements shall be designed, selected and installed to perform indefinitely throughout this temperature range.
3. Engine exhaust pipe shall be installed with anchors, guides and expansion joints for thermal expansion. Anchors shall be located below roof line to structure as to not impose pipe stresses upon double wall duct system. Also at wall penetration to cell as to not impose pipe forces on the test cell fire / blast resistant wall. All exhaust piping shall be insulated for a maximum 140 deg. F outer jacket temperature (based upon 500 deg F internal operating temp.) for personal protection.

4. Expansion devices shall be located and installed to prevent over stressing the engine exhaust duct (piping) at an operating temperature up to 700 deg. F.

D. Engine Exhaust Ductwork Installed Above Roof

1. Erect duct on support structure in suitably large sections without damage. At the Contractor's option, large sections may be shop assembled and shipped to the job site.
2. Locate and install pipe, duct, fixed supports and full ring slide supports, nominally at points indicated. Verify amount of mid-span structural steel deflection; adjust and shim/tack weld/bolt slides, dead-level, progressively in direction of expansion so that at cold and hot extreme motion position, duct load bears with 100% surface contact on supporting fixed slide surface and so that the load on the full ring sliding surfaces does not exceed 200 psi when hot and so that duct/pipe joint does not pass through supports. Support lengths are to be spaced as shown on the Drawings. Point and edge loading of support surfaces is not acceptable. Seal non-welded edges of supports to their supporting surface watertight by use of high temperature silicone caulk.
3. Install supplementary support steel as required to prevent the double wall insulated duct from sagging
4. Install in accordance with special requirements for specified devices and operating conditions
5. Install dampers (valves) with shafts oriented horizontally.
6. Refer to following for additional quality control requirements.

3.7 FIELD QUALITY CONTROL

A. Perform air leakage test in presence of Owner before concealment of any portion of the duct system.

B. Ductwork and hooding shall be so constructed as to present neat and workmanlike appearance and shall be independently supported and braced so as to be rigid and free from vibrations and noise when in service.

C. Engine Exhaust:

1. Installation of engine exhaust header and engine exhaust branch duct installation shall be inspected and approved in writing for submission to Owner by a qualified representative of the double wall insulated duct manufacturer.
2. Contractor shall mark all cold duct/pipe sliding support positions, confirm and mark all hot positions when all cells are operating under normal conditions
3. Similarly, mark positions of expansion joints. Check anchors for deformation.
4. Check all supports for uniform load bearing on sliding surfaces; adequate supported travel distance without crossing duct joints; point or edge loading; caulking. Deliver a "Hot/Cold Device Location/Status Matrix Report" to the Owner/Architect/Engineer and for insertion in O&M Manual.
5. Inspect duct/pipe overall surfaces, expansion joints, elbows, flanges for inadequately insulated hot spots and repair same.
6. Test duct for electrical continuity and grounding of internal duct of double wall ductwork and make repairs necessary to achieve continuity.

7. In the event that the Owner deems it necessary, during the warranty period, to test, additionally to Contract required testing, the thermal/mechanical performance of the duct insulation by Infra-Red Thermography, the Contractor shall be so advised by the Owner and shall be present during such testing. If unacceptable failures are indicated, the Contractor shall pay for cost thereof including retesting to confirm compliance after making corrections.

3.8 WORK PERFORMED BY OTHERS

A. A 3rd party, independent balancing Contractor shall provide air balance and testing.

B. The Plant Engineer shall provide machine drop locations.

END OF SECTION

SECTION 23 36 00

VAV UNIT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Shutoff, single-duct air terminal units.
   2. Parallel, fan-powered air terminal units.
   3. Series, fan-powered air terminal units.
   4. Casing liner.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For air terminal units.

   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Size and location of initial access modules for acoustic tile.

3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Instructions for resetting minimum and maximum air volumes.
b. Instructions for adjusting software set points.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

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

1. Carnes Company.
2. Johnson Controls.
3. Nailor Industries Inc.
4. Price Industries.
5. Titus.
6. Trane.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: Galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass

flexible elastomeric duct liner.

2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections[**, size matching inlet size**].
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 3 percent of nominal airflow at 6-inch wg inlet static pressure.
2. Damper Position: Normally open.

F. Attenuator Section:

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass flexible elastomeric duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

G. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. SCR controlled.
2. Access door interlocked disconnect switch.
3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
4. Nickel chrome 80/20 heating elements.
5. Airflow switch for proof of airflow.
6. Fan interlock contacts.
7. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
8. Mercury contactors.
9. Pneumatic-electric switches and relays.
10. Magnetic contactor for each step of control (for three-phase coils).

H. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Electronic Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
3. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
4. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and

maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.

5. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

6. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

I. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat.

2.3 PARALLEL FAN-POWERED AIR TERMINAL UNITS

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

1. Carnes Company.
2. Johnson Controls.
3. Nailor Industries Inc.
4. Price Industries.
5. Titus.
6. Trane.

B. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud. Designed for quiet operation.

C. Casing: Galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass flexible elastomeric duct liner.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal, located at plenum air inlet.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-

lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 3 percent of nominal airflow at 6-inch wg inlet static pressure.
2. Damper Position: Normally open.

E. Velocity Sensors: Multipoint array with velocity sensors.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Type: Electronically commutated motor.
3. Fan-Motor Assembly Isolation: Rubber isolators.

G. Filters:

1. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
2. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
3. Material: Pleated cotton-polyester media, MERV 7.
4. Thickness: 1 inch.

H. Attenuator Section:

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass flexible elastomeric duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Location: Plenum air inlet.
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).

J. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power

source.

2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

L. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
1. Electronic Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
3. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
4. Terminal Unit Controller: Pressure-independent, VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

5. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

2.4 SERIES FAN-POWERED AIR TERMINAL UNITS

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

1. Carnes Company.
2. Johnson Controls.
3. Nailor Industries Inc.
4. Price Industries.
5. Titus.
6. Trane.

B. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling and within a raised access floor.

1. Designed for quiet operation.
2. Low-profile design.

C. Casing: Galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass flexible elastomeric duct liner.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 3 percent of nominal airflow at 6-inch wg inlet static pressure.
2. Damper Position: Normally [**open**] [**closed**].

E. Velocity Sensors: Multipoint array with velocity sensors in air inlets and air outlets.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Type: Electronically commutated motor.
3. Fan-Motor Assembly Isolation: Rubber isolators.

G. Filters:

1. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
2. Material: Pleated cotton-polyester media MERV 7.
3. Thickness: 1 inch.

H. Attenuator Section:

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass flexible elastomeric duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
1. SCR controlled.
2. Access door interlocked disconnect switch.
3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).

4. Nickel chrome 80/20 heating elements.
5. Airflow switch for proof of airflow.
6. Fan interlock contacts.
7. Fuses in terminal box for overcurrent protection (for coils more than 48 A).

J. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

L. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
1. Electronic Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
3. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
4. Terminal Unit Controller: Pressure-independent, VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

a. Occupied and unoccupied operating mode.
b. Remote reset of airflow or temperature set points.
c. Adjusting and monitoring with portable terminal.
d. Communication with temperature-control system specified in Division 23 Section "Instrumentation and Control for HVAC."

2.5 CASING LINER

A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Minimum Thickness: 1 inch.

a. Maximum Thermal Conductivity:

1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean

temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

B. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 3/4 inch.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.3 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

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.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

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

END OF SECTION

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SECTION 23 37 13

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.

B. This Section is intended to replace the following AIA Sections:

1. Section 23 37 13.13 “Air Diffusers”
2. Section 23 37 13.23 “Air Registers and Grilles”
3. Section 23 37 13.43 “Security Registers and Grilles”

1.2 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.
2. Industrial radial vane diffusers.
3. High-capacity drum louver diffusers.
4. Registers and Grilles.
5. Fixed face registers and grilles.

B. Related Sections:

1. Section 23 33 00 "Air Duct Accessories."

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 Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
3. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
4. Security Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.

C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.

D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.

E. Samples: For each exposed product and for each color and texture specified. Smallest size register and grille indicated.

F. Samples for Initial Selection: For registers and grilles with factory-applied color finishes. Smallest size register and grille indicated.

G. Samples for Verification: For registers and grilles, in manufacturer's standard sizes to verify color selected. Smallest size register and grille indicated.

H. Samples for Initial Selection: For registers and grilles with factory-applied color finishes.

I. Samples for Verification: For registers and grilles, in manufacturer's standard sizes to verify color selected.

1.4 SOURCE QUALITY CONTROL.

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

PART 2 - PRODUCTS

2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

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

1. Titus
2. Hart & Cooley Inc.
3. Price Industries
4. Tuttle & Bailey
5. Nailor Industries Inc.
6. Or Approved Equal

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: Steel

D. Finish: Baked enamel, white

E. Face Size: Refer to Drawings

F. Face Style: Refer to Drawings

G. Mounting: Refer to Drawings

H. Pattern: Adjustable or Refer to Drawings

I. Dampers: Opposed blade Refer to Drawings

J. Accessories:

1. Equalizing grid.
2. Plaster ring.
3. Safety chain.
4. Wire guard.
5. Sectorizing baffles.
6. Operating rod extension.

2.2 HIGH-CAPACITY DRUM LOUVER DIFFUSERS

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

1. Titus
2. Hart & Cooley Inc.
3. Price Industries
4. Tuttle & Bailey
5. Nailor Industries Inc.
6. Or Approved Equal

B. Airflow Principle: Extended distance for high airflow rates.

C. Material: Aluminum, heavy gage extruded.

D. Finish: White baked acrylic.

E. Border: 1-1/4-inch (32-mm) width with countersunk screw holes.

F. Gasket between drum and border.

G. Body: Drum shaped; adjustable vertically.

H. Blades: Individually adjustable horizontally.

I. Mounting: Refer to Drawings.

J. Inlet Width: Refer to Drawings.

K. Inlet Length: Refer to Drawings.

L. Accessories:

1. Opposed-blade steel damper.
2. Duct-mounting collars with countersunk screw holes.

2.3 INDUSTRIAL RADIAL VANE DIFFUSER

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

1. Titus
2. Ruskin
3. American Warming
4. Tuttle & Bailey
5. Or Approved Equal

B. Size: As indicated on Drawings.

C. Mounting: See detail on Drawings.

D. Construction:

1. Frame shall be minimum 4 inches by 2 inches by 12 gage (102mm by 51mm by 2.8mm) galvanized steel angle with single flange.
2. Blades shall be individually adjustable. Constructed of a minimum 14 gage (2.0) galvanized steel.
3. Axles shall be minimum 1/2 inches (13 mm) diameter plated steel running full length of blade and welded at both ends.
4. A minimum four mounting straps for units through 36 inches (914 mm) diameter and six mounting straps for units above 36 inches (914 mm) diameter. Mounting straps shall be constructed of minimum 10 gage (3.5) galvanized steel.
5. Units shall be finished with white epoxy enamel finish.
6. Radial Vane Diffuser dampers shall be rated for minimum 200°F (93°C).

2.4 REGISTERS

A. Fixed Face Register:

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

a. Hart & Cooley Inc.
b. Nailor Industries Inc.

c. Price Industries.
d. Titus.
e. Tuttle & Bailey.
f. Or Approved Equal

2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Refer to Drawings.
5. Face Arrangement: Perforated core.
6. Core Construction: Removable.
7. Frame: 1-1/4 inches (32 mm) wide.
8. Mounting Frame: Refer to Drawings.
9. Refer to Drawings.
10. Damper Type: Refer to Drawings.
11. Accessory: Refer to Drawings.

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 level and plumb.

B. Install registers and grilles level and plumb.

C. 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.

D. 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.

END OF SECTION

SECTION 23 51 00

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.

B. This Section is intended to replace the following AIA Sections:

1. Section 23 51 13 “Draft Control Devices”
2. Section 23 51 13.13 “Draft-Induction Fans”
3. Section 23 51 13.16 “Vent Dampers”
4. Section 23 51 13.19 “Barometric Dampers”
5. Section 23 51 16 “ Fabricated Breechings and Accessories”
6. Section 23 51 19 “Fabricated Stacks”
7. Section 23 51 23 “Gas Vents”
8. Section 23 51 33 “Insulated Sectional Chimneys”

1.2 SUMMARY

A. This Section includes the following:

1. Listed single or double-wall vents and chimneys.

1.3 SUBMITTALS

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

1. Type B and BW vents.
2. Type L vents.
3. Special gas vents.

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.

C. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Section 23 05 48 "Vibration and Seismic Controls for HVAC." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
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.

D. Operation and Maintenance Data: For draft control devices to include in emergency, operation, and maintenance manuals.

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. Source Limitations: Obtain listed system components through one source from a single manufacturer.

C. 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.

D. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 72 00 "Roof Accessories."

1.6 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 GENERAL REQUIREMENTS

A. Combustion stacks: Height shall meet the requirements of State or local codes.

B. Stack: Self-supporting, of size and configuration indicated and fabricated from ASTM A242 steel with 0.41% copper content..

C. Breeching: Suitable for the installation and fabricated from the same material as the stack.

D. Insulation: Insulate both stack and breeching per Section 20 07 00 “Thermal Insulation for Mechanical, Plumbing and Fire Suppression.”

2.2 LISTED TYPE B AND BW VENTS

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

1. Selkirk
2. M&G DuraVent

B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B, or 550 deg F (288 deg C) continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.

D. Inner Shell: ASTM B 209 (ASTM B 209M), Type 3105 aluminum or ASTM A 666, Type 430 stainless steel.

E. Outer Jacket: Aluminized steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Antibackdraft.

2.3 LISTED TYPE L VENTS

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

1. Selkirk
2. M&G DuraVent

B. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F (300 deg C) continuously, or 1700 deg F (926 deg C) 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 (50-mm) airspace filled with high-temperature, ceramic-fiber insulation.

D. Inner Shell: ASTM A 666, Type304 stainless steel.

E. Outer Jacket: Aluminized steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude 90 percent of rainfall.

2.4 GUYING AND BRACING MATERIALS

A. Cable: Three galvanized, stranded wires of the following thickness:

1. Minimum Size: 1/4 inch (6 mm) in diameter.
2. For ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).

B. Pipe: Two or Three galvanized steel, NPS 1-1/4 (DN 32).

C. Angle Iron: Two or Three galvanized steel, 2 by 2 by 0.25 inch (50 by 50 by 6 mm).

2.5 VENT DAMPERS

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

1. Effikal International
2. Field Controls LLC
3. Johnson Controls, Inc
4. Or Approved Equal

B. Damper Construction: Stainless-steel damper blade, shaft, and vent pipe with metal, prelubricated bearings.

1. Electric motor sized to power damper open and closed in approximately 15 seconds in each direction. Power is off when damper is at rest.
2. Comply with ANSI Z21.66.

C. Controls:

1. Control transformer.

2. Keyed wiring harness.
3. Damper end-switch to prove damper is open.
4. Interlock with boiler to permit burner operation when damper is open.
5. Hold-open switch for troubleshooting boiler controls.

D. Capacities and Characteristics

1. Refer to Drawings

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 Chimney Liners: High-efficiency boiler or furnace vents in masonry chimney, dishwasher exhaust, or Type II commercial kitchen hood.

B. Listed Type B and BW Vents: Vents for certified gas appliances.

C. Listed Type L Vent: Vents for low-heat appliances.

D. Listed Special Gas Vent: Condensing gas appliances.

E. Listed Building-Heating-Appliance Chimneys: Dual-fuel boilers, oven vents, water heaters, and exhaust for engines. Fireplaces and other solid-fuel-burning appliances.

F. Listed Grease Ducts: Type I commercial kitchen grease duct.

G. Listed, Refractory-Lined Metal Breechings and Chimneys: Freestanding dual-fuel boiler vents, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

H. Field-Fabricated Metal Breechings and Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

I. Field-Fabricated Metal Breechings and Chimneys: Steel pipe for use with engine exhaust.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

D. Lap joints in direction of flow.

E. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

F. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

G. Erect stacks plumb to finished tolerance of no more than 1 inch (25 mm) out of plumb from top to bottom.

3.4 INSTALLATION OF UNLISTED, FIELD-FABRICATED BREECHINGS AND CHIMNEYS

A. Suspend breechings and chimneys independent of their appliance connections.

B. Install, support, and restrain according to seismic requirements.

C. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch (3-mm) misalignment tolerance.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

3.5 INSTALLATION OF DRAFT CONTROL DEVICES

A. Install listed components in a manner complying with the listing.

B. Secure barometric dampers to breechings with hardware compatible with connected materials.

C. Locate barometric and motorized vent dampers as close to draft hood collar as possible.

D. Secure barometric and motorized vent dampers to appliances, breechings, or chimneys with hardware compatible with connected materials.

E. Install draft inducer fans in single-wall vent section that is designed to couple with other vent materials.

F. Secure draft inducer fans to appliances, breechings, or stacks with hardware compatible with connected materials.

G. Install draft inducer fans with clearances for service and maintenance.

H. Install [**PVC**] intake duct that is sized according to manufacturer's written instructions.

3.6 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.7 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.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. Remove and replace malfunctioning components and recheck.

3.9 ADJUSTING

A. Set field-adjustable switches and controls as indicated.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain draft control devices. Refer to Section 017900 "Demonstration and Training."

END OF SECTION

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SECTION 23 55 00

FUEL-FIRED HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Natural Gas Fired Furnace.

B. Related Sections:

1. Section 23 05 13 - Common Motor Requirements for HVAC Equipment: Product requirements for electric motors for placement by this section.

2. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment: Product requirements for hangers for placement by this section.

3. Section 23 09 00 - Instrumentation and Control for HVAC: Product requirements for thermostats and time clocks for placement by this section.

4. Section 23 33 00 - Air Duct Accessories: Product requirements for flexible duct connections.

1.02 REFERENCES

A. American National Standards Institute:

1. ANSI Z83.8 - Gas Unit Heaters.

2. ANSI Z83.9 - Gas-Fired Duct Furnaces.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. National Fire Protection Association:

1. NFPA 31 - Standard for the Installation of Oil-Burning Equipment.

2. NFPA 54 - National Fuel Gas Code.

3. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

4. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

5. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel Burning Appliances.

D. Underwriters Laboratories Inc.:

1. UL 727 - Oil-Fired Central Furnaces.

2. UL 729 - Oil-Fired Floor Furnaces.

3. UL 731 - Standard for Safety for Oil-Fired Unit Heaters.

1.03 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Submittals procedures.

B. Shop Drawings: Indicate assembly, required clearances, and locations and sizes of field connections.

C. Product Data: Submit manufacturer's literature and data indicating rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

D. Manufacturer's Installation Instructions: Submit Indicate rigging and assembly.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.04 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution Requirements: Closeout procedures.

B. Project Record Documents: Record actual locations of thermostats or other products not mounted on unit.

C. Operation and Maintenance Data: Submit manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listing.

1.05 QUALITY ASSURANCE

A. Gas-Fired Unit Heater Performance Requirements: Conform to minimum efficiency prescribed by ASHRAE 90.1 when tested in accordance with ANSI Z83.8.

1.06 QUALIFICATIONS

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

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer.

1.07 PRE-INSTALLATION MEETINGS

A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.

B. Accept heaters and controls on site in factory packaging. Inspect for damage.

1.09 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Section 01 70 00 - Execution Requirements: Product warranties and product bonds.

B. Furnish ten year manufacturer warranty for heat exchanger.

1.11 EXTRA MATERIALS

A. Section 01 70 00 - Execution Requirements: Spare parts and maintenance products.

PART 2 - PRODUCTS

2.01 NATURAL GAS FIRED FURNACES

A. Manufacturers:

1. Basis of Design: Trane GMPD series, Modine
2. Approved equal: Carrier, York

B. General - Separated Combustion:

1. Unit is completely factory assembled, piped, wired, and test fired. Unit is ETL Certified and conforms with the latest ANSI Z83.8/CSA 2.6 Standards for safe and efficient performance. Unit is provided with four point suspension hangers.

C. Casing for L,M :

1. Casing is die-formed, 20 gauge cold rolled steel and finished in baked enamel. The bottom panel is easily removed to provide service access to the burners, pilot and orifices. Unit shall be provide with a air inlet and outlet duct flanges for use with field duct work.

D. Clamshell Heat Exchanger - 409 Stainless Steel:

1. Heat Exchanger construction consists of seam welded 20 gage type 409 stainless steel and 18 gage type 409 stainless steel headers. Unit shall have a minimum of 80% thermal efficiency.

E. Burners - 409 Stainless:

1. Burners are die-formed, type 409 stainless steel, with stainless steel port protectors. Port protectors prevent scale or foreign matter from obstructing the burner ports. Burners individually removable for ease of inspection and servicing. Each burner is provided with an individually adjustable, manually rotated air shutter adjustment.

F. Flue Vent Fan:

1. Flue vent fan provides power venting. Provided factory assembled to a sealed flue collection chamber.

G. Combustion Chamber-Separated Combustion Unit:

1. Combustion chamber shall be completely sealed to prevent infiltration of air from the space into the combustion burner.

H. Motor-ODP:

1. Motor is open drip proof with built in thermal overload protection.

I. Control - Separated Combustion Duct Furnace:

1. A factory installed junction box is provided for all power connections. Standard units are provided with a 24-volt combination single-stage redundant gas valve, consisting of a combination pilot solenoid valve, automatic electric gas valve, pilot filter, pressure regulator, pilot adjustment and manual shutoff. A flue vent fan relay and combustion air proving switch is also provided as standard. Standard equipment includes spark-ignited intermittent pilot system with electronic flame supervision. A 24-volt control transformer, and high limit and fan time delay relay are provided.

J. Electronic Modulating with Duct Thermostat:

1. Provides modulated heat output. Ignition is at full fire (100% input) and modulates the gas input from 100% to 40% rated input. Supplied with 4-20 mA or 0-10 VDC input for use with building automation system.

K. General:

1. Units are completely factory assembled and have four point suspension hangers and filter racks as standard. Casings are 18 gage galvanized steel with baked enamel finish. Side panels are removable for easy servicing and motor maintenance. Duct flanges are provided for simple ductwork connection. Standard filters are 1" permanent washable type. Factory mounted motors are open drip proof, with built-in thermal overload protection. Centrifugal fan is belt driven with adjustable pitch motor sheaves. Motor and fan are dynamically balanced for quiet operation. Blower assembly is insulated with fire resistant, odorless, matt faced 1" thick glass fiber material.

L. Transition:

1. When used with a duct furnace, a sheet metal transition is supplied to connect the blower assembly to the duct furnace. Transition is insulated with fire resistant, odorless, matt faced 1" thick glass fiber material.

M. Insulation:

1. Blower assembly is insulated with fire resistant, odorless, matt faced 1" thick glass fiber material.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Verify space is ready for installation of units and openings are as indicated on shop drawings.

3.02 INSTALLATION

A. Install units in accordance with NFPA 90A gas fired units to NFPA 54.

B. Installation - Natural Gas Piping:

1. Connect Natural Gas piping in accordance with NFPA 58.

2. Connect Natural Gas piping to unit, full size of unit gas train inlet. Arrange piping with clearances for burner service.

3. Install the following piping accessories on Natural Gas piping connections.
   a. Strainer.
   b. Pressure gage.
   c. Shutoff valve.
   d. Pressure reducing valve.

C. Install packaged air units with vibration isolation.

D. Provide hangers and supports for suspended units. Support infrared radiant heaters in fixed position.

E. Provide hangers and supports for suspended units.

F. Provide operating controls.

G. Provide connection to electrical power systems.

END OF SECTION

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SECTION 23 81 26

SPLIT-SYSTEM AIR-CONDITIONERS

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 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. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

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, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

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

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 Section 033000 "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 Compressor: One year from date of Substantial Completion.
b. For Parts: Five year(s) from date of Substantial Completion.
c. For Labor: One year from date of Substantial Completion.

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 of the following:

1. Carrier Corporation; a unit of United Technologies Corp.
2. Trane.
3. Or Approved Equal

2.2 INDOOR UNITS

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.

2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve.
4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
5. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
6. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 200513 "Common Motor Requirements for Mechanical, Plumbing and Fire Suppression."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Wiring Terminations: Connect motor to chassis wiring with plug connection.

7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
8. Filters: Permanent, cleanable.
9. Condensate Drain Pans:

    a. Fabricated with one 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 to comply with ASHRAE 62.1.
        2) Depth: A minimum of 2 inches (50 mm) deep.

    b. Double-wall, galvanized-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
    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 (DN 25) or per manufacturer specifications.

    d. Pan-Top Surface Coating: Asphaltic waterproofing compound.

2.3 OUTDOOR UNITS

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: Refer to drawings
    b. Variable-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    c. Refrigerant Charge: Refer to Drawings
    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 45 deg F (7 deg C).
7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. 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.

D. Drain Hose: For condensate.

E. Additional Monitoring:

1. Monitor constant and variable motor loads.
2. Monitor variable-frequency-drive operation.

2.5 CAPACITIES AND CHARACTERISTICS

A. Refer to Drawings

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install unit(s) 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 Section 07 72 00 "Roof Accessories." Section 07 72 00 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

3.2 CONNECTIONS

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

B. Duct Connections: Duct installation requirements are specified in Section 23 31 00 "Ductwork and HVAC Casings" Drawings indicate the general arrangement of ducts. Connect supply and return and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 23 33 00 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. 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.

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

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions. Confirm that installed equipment is functioning per Client and manufacturer specifications.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

SECTION 26 00 10

GENERAL REQUIREMENTS 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 1 Specification sections, apply to work of this section.

B. Division 01, Commissioning Requirements, applies to this section and will require the contractor participation in the commissioning process.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for electrical systems provided under CSI Divisions 26 and 28. The following requirements are included in this Section to supplement the requirements specified in Division 1 Specification Sections.

1.3 QUALITY ASSURANCE

A. Scope of Work: Furnish all labor, material, equipment, technical supervision, and incidental services required to complete, test and leave ready for operation the electrical systems as specified in the Divisions 26 and 28 Specification sections and as indicated on Drawings

B. Codes and Standards: Perform all Work in accordance with applicable Federal, State and local codes rules, ordinances and regulations. The electrical and physical properties of all materials, and the design, performance characteristics, and methods of construction of all items of equipment, shall be in accordance with the latest issue of the various, applicable Standards, Rules and Regulations of NFPA, NECA, UL, and as follows unless otherwise indicated.

1. A.N.S.I. - American National Standards Institute
2. A.S.T.M. - American Society for Testing Materials
3. I.C.E.A. - Insulated Cable Engineers Association
4. I.E.E.E. - Institute of Electrical and Electronics Engineers
5. N.E.C. - National Electrical Code (NFPA 70 and 70B)
6. N.E.C.A. -National Electrical Contractors Association
7. N.E.M.A. - National Electrical Manufacturer's Association
8. U.L. - Underwriters Laboratories, Inc.
9. Local, City, State, and National Codes
10. NFPA National Fire Protection Association (NFPA 70 and 70-E)

11. NESC National Electrical Safety Code
12. OSHA Occupational Safety and Health Administration
13. Rules of the Local Electrical Utility
14. Life Safety Code 101
15. Rules of the Local Electrical Utility
16. Local, City, State, and National Codes

C. Where available products included in the work shall be Listed or be Certified by a nationally recognized testing laboratory. The listing or certification shall be acceptable to the authority having jurisdiction. The listing or certification shall indicate that the product's safety-related standards have been evaluated with regard to all reasonably foreseeable safety-related hazards, including fire, electrical shock and mechanical hazards.

D. Notify the Architect/Engineer before submitting a proposal should any changes in Drawings or Specifications be required to conform to the above codes, rules or regulations. After entering into Contract, make all changes required to conform to above ordinances, rules and regulations without additional expense to the Owner.

E. All materials shall be new unless indicated otherwise to reuse existing equipment.

F. Limitations: All equipment of the same or similar systems shall be by the same manufacturer. Source.

G. Tests and Inspections: Perform all tests required by state, city, county and/or other agencies having jurisdiction. Provide all materials, equipment, etc., and labor required for tests. When installation of a system has been completed, the equipment shall be operated as directed by Owner's Representative. Replace faulty equipment and make required adjustments before final acceptance.

H. Performance Requirements: Perform all work following practices for good workmanship, in accordance with the latest accepted standards and practices for the trades involved.

I. Sequence and Schedule: Work so as to avoid interference with the work of other trades. Be responsible for removing and relocating any work which in the opinion of the Owner's Representatives causes interference.

1.4 CODES, PERMITS AND FEES

A. Unless otherwise indicated, all required permits, licenses, inspections, approvals and fees for electrical work shall be secured and paid for by the Contractor.

B. Contractor shall be responsible for all fees for permits, inspections, and tests necessary to complete this work. Contractor shall demonstrate to the AHJ and the Engineer that all items of equipment installed are completely operational and free of defects under all operating conditions.

C. Rules of local utility companies shall be complied with. Coordinate with the utility companies supplying service to the installation and determine all required interface devices, including the following, and include the cost of all such items and all utilities costs in proposal. Including.

1. All current and potential transformers,
2. Meter boxes,
3. C.T. cabinets and meters which will be required.
4. Surge protection,
5. Raceway sizes,
6. Connection points.

D. Prepare any detailed Drawings or diagrams which may be required by the governing authorities or authorities having jurisdiction. Where the Drawings and/or Specifications indicate materials or construction in excess of code requirements, the Drawings and/or Specifications shall govern.

E. Contractor to provide Arc Flash labels according to NFPA 70E Standards for Electrical Safety in the Workplace.

1.5 DRAWINGS

A. The Drawings show the location and general arrangement of equipment, electrical systems and related items. They shall be followed as closely as elements of the construction will permit.

B. Examine the Drawings of other trades and verify the conditions governing the work on the job site. Arrange work accordingly, providing such fittings, conduit, junction boxes and accessories as may be required to meet such conditions.

C. Deviations from the Drawings, with the exception of minor changes in routing and other such incidental changes that do not affect the functioning or serviceability of the systems, shall not be made without the written approval of the Architect/Engineer.

D. The architectural and structural Drawings take precedence in all matters pertaining to the building structure, mechanical Drawings in all matters pertaining to mechanical trades and electrical Drawings in all matters pertaining to electrical trades. Where there are conflicts or differences between the Drawings for the various trades, report such conflicts or differences to the Architect/Engineer for resolution.

E. Drawings are not intended to be scaled for rough-in or to serve as shop drawings. Take all field measurements required to complete the Work.

1.6 MATERIAL AND EQUIPMENT MANUFACTURERS

A. All items of equipment shall be furnished complete with all accessories normally supplied with the catalog items listed and all other accessories necessary for a complete and satisfactory operating system. All equipment and materials shall be new and shall be standard products of

manufacturers regularly engaged in the production of electrical equipment and shall be of the manufacturer's latest design.

B. If an approved manufacturer is other than the manufacturer used as the basis for design, the equipment or product provided;

1. Shall be equal in size, quality, durability, appearance, capacity, and efficiency through all ranges of operation,
2. Shall conform with arrangements and space limitations of the equipment shown on the plans and/or specified,
3. Shall be compatible with the other components of the system, and
4. If not of a listed or approved manufacturer, shall comply with the requirements outlined in Substitutions section in Division 1 of the Specifications.

C. All costs to make these items of equipment comply with these requirements including, but not limited to, electrical work, mechanical work, controls work, technology work and building alterations shall be included in the original Bid.

1.7 INSPECTION OF SITE

A. Visit the site, examine and verify the conditions under which the Work must be conducted before submitting Proposal. The submitting of a Proposal implies that the Contractor has visited the site and understands the conditions under which the Work must be conducted. No additional charges will be allowed because of failure to make this examination or to include all materials and labor to complete the Work.

1.8 ITEMS REQUIRING PRIOR APPROVAL

A. Bids shall be based upon manufactured equipment specified. All items that the Contractor proposes to use in the Work that are not specifically named in the Contract Documents must be submitted for review prior to bids. Such items must be submitted in compliance with Division 1 specifications. Requests for prior approval must be accompanied by complete catalog information, including but not limited to, model, size, accessories, complete electrical information and performance data in the form given in the equipment schedule on the drawings at stated design conditions. Where items are referred to by symbolic designations on the drawings, all requests for prior approval shall bear the same designations.

1. Equipment to be considered for prior approval shall be equal in quality, durability, appearance, capacity and efficiency through all ranges of operation, shall fulfill the requirements of equipment arrangement and space limitations of the equipment shown on the plans and/or specified and shall be compatible with the other components of the system.
2. All costs incurred to make equipment comply with other requirements, including providing maintenance, clearance, electrical, replacement of other components, and building alterations shall be included in the original bid.

B. Voluntary alternates may be submitted for consideration, with listed addition or deduction to the bid.

1.9 SHOP DRAWINGS/SUBMITTALS

A. Submit project-specific submittals for review in compliance with Division 1.

B. All shop Drawings shall be submitted in groupings of similar and/or related items (lighting fixtures, switchgear, etc.). Incomplete submittal groupings will be returned unchecked.

C. If deviations (not substitutions) from Contract Documents are deemed necessary by the Contractor, details of such deviations, including changes in related portions of the project and the reasons therefore, shall be submitted with the submittal for approval.

D. Submit for approval shop drawings for all electrical systems and equipment as listed below. Where items are referred to by symbolic designation on the Drawings and in the Specifications, all submittals shall bear a similar designation (light fixtures, wiring devices, etc.) as identified on the Drawings and in the Specifications and shall be submitted together and under the same cover, unless requested otherwise. Refer to other sections of the electrical Specifications for additional requirements.

1. Underfloor Raceways
2. Cable Trays
3. Wiring Devices
4. Lighting Control Devices
5. Electrical Power Monitoring and Control
6. Packaged Engine Generators
7. Static Uninterruptible Power Supply
8. Central Battery Equipment
9. Enclosed Switches and Circuit Breakers
10. Transfer Switches
11. Enclosed Controllers
12. Low Voltage Switchgear
13. Switchboards
14. Panelboards
15. Motor Control Centers
16. Enclosed Bus Assemblies
17. Dry Type Transformers (600 V and Less)
18. Fuses
19. Interior Lighting
20. Programmable Lighting Controls
21. Exterior Lighting
22. Dimming Controls
23. Fire Alarm
24. Underground Ducts and Raceways

1.10 COORDINATION DRAWINGS

A. Submit project specific coordination drawings for review in compliance with Division 1 Specification Sections.

1.11 OPERATION AND MAINTENANCE INSTRUCTION MANUALS

A. Submit project specific Operation and Maintenance Instructional Manuals for review in compliance with Division 1 Specification Sections.

B. Provide complete operation and maintenance instructional manuals covering all electrical equipment herein specified, together with parts lists. Maintenance and operating instructional manuals shall be job specific to this project. Generic manuals are not acceptable. Four (4) copies of all literature shall be furnished for Owner and shall be bound in ring binder form. Maintenance and operating instructional manuals shall be provided when construction is approximately 75% complete.

C. The operating and maintenance instructions shall include a brief, general description for all mechanical systems including, but not limited to:

1. Routine maintenance procedures.
2. Lubrication chart listing all types of lubricants to be used for each piece of equipment and the recommended frequency of lubrication.
3. Trouble-shooting procedures.
4. Contractor's telephone numbers for warranty repair service.
5. Submittals.
6. Recommended spare parts lists.
7. Names and telephone numbers of major material suppliers and subcontractors.
8. System schematic drawings on 8-1/2" x 11" sheets.

D. Maintenance Materials

1. Retain all portable and detachable portions of the installation, keys, tools, etc. and turn over to the Owner.

E. Equipment Labels

1. Provide an arc flash protection label for each piece of electrical equipment containing over 50 volts. Coordinate the labels with the Arc Flash Protection Study.
2. Lockout Placards shall be provided on electrical equipment, when required by the Owner, that show energy source locations, means to lockout, verification procedures, and awareness items in accordance with Client standards.

1.12 RECORD DRAWINGS

A. Submit record drawings in compliance with Division 1.

B. Contractor shall submit to the Architect/Engineer, record drawings on electronic media or Mylar which have been neatly marked to represent as-built conditions for all new electrical work.

C. The Contractor shall keep accurate note of all deviations from the construction documents and discrepancies in the underground concealed conditions and other items of construction on field drawings as they occur. The marked up field documents shall be available for review by the Architect, Engineer and Owner at their request.

1.13 INSTRUCTION OF OWNER PERSONNEL

A. Before final inspection, instruct Owner's designated personnel in operation, adjustment, and maintenance of electrical equipment and systems at agreed upon times. A minimum of 8 hours of formal instruction to Owner's personnel shall be provided for each building. Additional hours are specified in individual specification sections.

B. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

C. In addition to individual equipment training provide overview of each electrical system. Utilize the as-built documents for this overview.

D. Prepare and insert additional data in operation and maintenance manual when need for such data becomes apparent during instruction, or as requested by Owner.

1.14 WARRANTY

A. Warranty: Comply with the requirements in Division 1 Specification Sections. Contractor shall warranty that the electrical installation is free from defects and agrees to replace or repair, to the Owner’s satisfaction, any part of this electrical installation which becomes defective within a period of one year (unless specified otherwise in other Division 26, 27 or 28 sections) from the date of substantial completion following final acceptance, provided that such failure is due to defects in the equipment, material, workmanship or failure to follow the contract documents.

B. Contractor shall be responsible for any and all temporary services including equipment and installation required to maintain operation as a result of any equipment failure or defect during warranty period.

C. File with the Owner any and all warranties from the equipment manufacturers including the operating conditions and performance capacities they are based on.

1.15 USE OF EQUIPMENT

A. The use of any equipment, or any part thereof for purposes other than testing even with the Owner's consent, shall not be construed to be an acceptance of the work on the part of the

Owner, nor be construed to obligate the Owner in any way to accept improper work or defective materials.

B. Do not use Owner's lamps for temporary lighting except as allowed and directed by the Owner. Equip lighting fixtures with new lamps when the project is turned over to the Owner.

1.16 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.

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 8 Section "Access Doors and Frames."

D. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.17 DELIVERY, STORAGE, AND HANDLING

A. Accept electrical equipment on site. Inspect for damage.

B. Protect electrical equipment from corrosion and entrance of debris by storing above grade. Provide appropriate covering. Store indoor if possible. If stored outdoor, store off of ground, and in such a way to provide air circulation and allow water to drain off.

C. Protect PVC conduit from sunlight

PART 2 - PRODUCTS

2.1 REFERENCE TO DRAWINGS

A. Reference shall be made to Drawing Schedules, Details, Notes, and manufacturer's specifications for: Manufacturer, model, catalog number, size, capacity, performance, ratings and installation of equipment and material.

2.2 CHOICE OF MATERIALS AND EQUIPMENT

A. In submitting substitutions, bidders should note the following minimum considerations: (1) capacities shown are absolute minimal and must be equaled, (2) physical size limitations for space allotted, (3) structural properties, (4) noise level, (5) interchangeability, (6) compatibility with other materials and assemblies, (7) similar items shall be same manufacture and style wherever possible.

B. All material and equipment, for which a UL, ANSI, or a NEMA Standard is established, shall be so approved and labeled or stamped.

C. Adhesives are not acceptable as a mounting, supporting, or assembling technique, unless noted otherwise.

2.3 ELECTRICAL EQUIPMENT

A. NEMA standards shall be taken as minimum requirements for electrical equipment.

B. Equipment shall operate properly under a plus or minus 10 percent voltage variation.

2.4 SUBMITTALS DURING CONSTRUCTION

A. Provide complete manufacturers' descriptive information and shop drawings for all equipment, material and devices furnished under Division 26, Electrical, including certified outline drawings, arrangement drawings, elementary (schematic) diagrams, interconnection and connection diagrams, in accordance with provisions elsewhere in these Contract Documents. Provide the number of copies specified herein for the Engineer, Contractor and Operation and Maintenance Manuals.

B. Provide certified shop drawings, literature and requested samples showing items proposed for use, size, dimensions, capacity, special features required, schematic (elementary) control diagrams, equipment schedules, rough-in, etc., as required by the Engineer for complete review and for use during installation.

C. Use NEMA device designations and symbols for all electric circuit diagrams submitted. Make content of the schematic (elementary) connection or interconnection diagrams in accordance with the latest edition of NEMA ICS 1.

D. Manufacturer's standardized elementary diagrams will not be acceptable unless applicable portions of the diagram have been clearly identified and non-applicable portions deleted or crossed out.

E. All submittals shall be made in accordance with Division 1, General Requirements.

F. Certified arrangement drawings, outline dimensions, and weights for all major (engineered) equipment including, but not limited to:

1. Low voltage panelboards.
2. Motor starters/disconnects.
3. Individually mounted circuit breakers.

G. Characteristic curves for all protective devices.

H. Certified drawings and descriptive literature for all equipment and devices furnished under Division 26 and 28, Electrical, and not listed above.

I. In addition to submittals for specific items mentioned above, furnish manufacturers product data on the following items:

1. Panelboards.
2. Separately mounted circuit breakers, fused switches, and non-fused disconnect switches.
3. Wireway.
4. Outlet and device boxes (Both interior and exterior surface mount).
5. Pull boxes and junction boxes.
6. Terminal junction boxes.
7. Power cable.
8. Lighting fixtures.
9. Emergency lighting units.
10. Ballasts/drives
11. Light poles.
12. Receptacles.
13. Light switches.
14. Device plates.
15. Control relays and timers.
16. Dry type small power transformers, 0-600V primary.
17. Automatic Transfer Switches
18. Generator sets

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items. If mounting heights are not indicated, install to provide maximum possible physical space for access after installation without adding a hazardous situation. Contact the Architect for direction.

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 raceways and piping systems installed at a required slope.

3.2 DEMOLITION WORK

A. All demolition of existing electrical equipment and materials will be done by this Contractor unless otherwise indicated. Include all items such as, but not limited to, electrical equipment, devices, lighting fixtures and associated conduit and wiring called out on the Drawings and as necessary whether such items are actually indicated on the Drawings or not in order to accomplish the installation of the specified new work.

B. In general, demolition work is indicated on the Drawings. However, the Contractor shall visit the job site to determine the full extent and character of this work.

C. Unless specifically noted to the contrary, removed materials shall not be reused in the work. Salvaged materials that are to be reused shall be stored safe against damage and turned over to the appropriate trade for reuse. Salvaged materials of value that are not to be reused shall remain the property of the Owner unless such ownership is waived. Items on which the Owner waives ownership shall become the property of the Contractor, who shall remove and legally dispose of same, away from the premises.

D. Where equipment or fixtures are removed, outlets shall be properly blanked off, and conduits capped. After alterations are done, the entire installation shall present a "finished" look, as approved by the Architect/Engineer. The original function of the present electrical work to be modified shall not be changed unless required by the specific revisions to the system as specified or as indicated.

E. Appropriately reroute lighting, power and technology wiring as required to maintain service to equipment and devices to remain. Where walls and ceilings are to be removed, the conduit is to be cut off by the Electrical Trades so that the abandoned conduit in these walls and ceilings may be safely removed. Plug the ends of conduits which cannot be removed and cannot be reused.

F. Where new walls and/or floors are installed which interfere with existing outlets, devices, etc., the Electrical Trades shall adjust, extend and reconnect such items as required to maintain continuity of same.

G. All electrical work in altered and unaltered areas shall be run concealed in finished spaces. Use of surface raceway or exposed conduits will be permitted only where approved by the Architect/Engineer.

H. Existing lighting shall be reused where indicated on plans. Reused fixtures shall be detergent cleaned, re-lamped and reconditioned suitable for satisfactory operation and appearance.

3.3 INSTALLATION OF EQUIPMENT

A. Install all equipment in strict accordance with all directions and recommendations furnished by the manufacturer. Where such directions are in conflict with the Drawings and Specifications, report such conflicts to the Architect/Engineer for resolution.

B. Prior to rough in, allow for flexibility, ten feet in any direction, in the final location of electrical system and wiring devices without additional cost to the Owner.

C. Furnish concrete foundations and supports for electrical equipment and materials as required by codes, client standards and as shown or noted on the Drawings .When noted on the drawings provide and install concrete bases 4" above the finished floor, with leveling channels, where noted, for floor mounted equipment such as unit substations, transformers, switchgear, switchboards, distribution panels, motor control centers, etc. Coordinated the locations of leveling channels with the architectural trades.

D. Painting

1. In general no painting is required by Electrical Trades other than touch up of factory finished electrical equipment.
2. All factory finished electrical equipment shall be cleaned at completion of the job. Equipment showing rust or scratches shall be thoroughly cleaned and sanded, prime coated and touched up with enamel of color to match original finish.

3.4 WORK IN EXISTING BUILDINGS

A. The Owner will provide access to existing buildings as required. Access requirements to occupied buildings shall be identified on the project schedule. The Contractor, once Work is started in the existing building, shall complete same without interruption so as to return work areas as soon as possible to Owner.

B. Adequately protect and preserve all existing and newly installed Work. Promptly repair any damage at Contractor's expense.

C. Consult with the Owner's Representative as to the methods of carrying on the Work so as not to interfere with the Owner's operation any more than absolutely necessary. Accordingly, all service lines shall be kept in operation as long as possible and the services shall only be interrupted at such time as will be designated by the Owner's Representative.

D. Prior to starting work in any area, obtain approval for doing so from a qualified representative of the Owner who is designated and authorized by the Owner to perform testing and abatement of all hazardous materials including but not limited to, asbestos. The Contractor shall not perform any inspection, testing, containment, removal or other work that is related in any way whatsoever to hazardous materials under the Contract.

3.5 TEMPORARY SERVICES

A. Provide and remove upon completion of the project, in accordance with the general conditions and as described in Division 1, complete temporary electrical and telecommunication (voice/data) services for use during construction.

3.6 DISPOSAL

A. Fluorescent Lamps

1. Fluorescent lamps are known to contain mercury and are classified as hazardous material. All fluorescent lamps shall be assumed to contain mercury unless tested and confirmed otherwise with a toxicity characteristic leaching procedure (TCLP).
2. Hazardous materials, including fluorescent lamps, shall be sent to a lamp recycling facility. The materials shall be properly packaged with labels that meet the Department of Transportation Regulations and stored in a secure location prior to transportation.
3. The Contractor shall identify the costs of the lamp disposal process including, but not limited to, the lamp packaging, storage, transportation, disposal, and any profile fees.
4. At the completion of the project, provide documentation to verify that the lamps have been properly disposed of in accordance with all local, state and federal guidelines.

B. Ballasts

1. Lighting ballasts manufactured prior to 1979 have been known to contain polychlorinated biphenyls (PCBs). Unless specifically noted on the ballast as containing "No PCBs," the ballast shall be assumed to contain components with PCB materials.
2. Hazardous materials (ballasts with PCBs), shall be disposed of at a hazardous waste incineration facility, or at a recycling facility in accordance with the Code of Federal Regulations as administered by the EPA in regards to this issue. The ballasts shall be packaged/stored in fifty-five gallon steel drums with labels that meet the Department of Transportation Regulations.
3. The Contractor shall identify the costs of the ballast disposal process including, but not limited to, the packaging, storage, transportation, disposal, and any profile fees.
4. Provide at completion of the project documentation (manifests) to verify that the ballasts have properly been disposed of in accordance with all local, state and federal guidelines.

3.7 ACCESS DOORS, CHASES AND RECESSES

A. Provided by the architectural trades, but the Contractor shall be responsible for their accurate location and size.

3.8 CUTTING, PATCHING AND DAMAGE TO OTHER WORK

A. Refer to General Conditions for requirements.

B. All cutting, patching and repair work shall be performed by the Contractor through approved, qualified subcontractors. Contractor shall include full cost of same in bid.

3.9 EXCAVATION AND BACKFILLING

A. Provide all excavation, trenching, tunneling, dewatering and backfilling required for the electrical work. Coordinate the work with other excavating and backfilling in the same area.

B. Where conduit is installed less than 2'6" below the surface of pavement, provide concrete encasement, 4" minimum coverage, all around or as shown on the electrical Drawings.

C. Backfill all excavations, away from wall footings, with well-tamped granular material.

1. Place granular backfill in layers not more than 8 inches in thickness, Compact each layer to 95 percent, Excavated material shall not be used.
2. Outside building, first place granular material, as indicated above, up to 12 inches over top of pipe. Backfill remainder of excavation with unfrozen, excavated material in such a way to prevent settling.

D. Backfill all excavations under wall footings with lean mix concrete up to underside of footings and extend concrete within excavation a minimum of four (4) feet each side of footing.

E. Install Underground Warning Tape above all underground duct bank installations.

3.10 EQUIPMENT CONNECTIONS

A. Make connections to equipment, motors, lighting fixtures, and other items included in the work in accordance with the approved Shop Drawings and rough-in measurements furnished by the manufacturers of the particular equipment furnished. All additional connections not shown on the Drawings, but called out by the equipment manufacturer's shop Drawings shall be provided

B. Provide electrical drops to equipment in conduit up to a certain elevation and supported at both ends. Exact location of process equipment electrical control panels shall be determined from manufacturers equipment drawings. The electrical drops shall be installed such that there is no interference with equipment that is in motion, such as cranes, jibs, gantries or robots.

3.11 CLEANING

A. All debris shall be removed daily as required to maintain the work area in a neat, orderly condition.

B. Final cleanup shall include, but not be limited to, washing of fixture lenses or louvers, switchboards, substations, motor control centers, panels, etc. Fixture reflectors and lenses or louvers shall be left with no water marks or cleaning streaks.

3.12 PROTECTION AND HANDLING OF EQUIPMENT AND MATERIALS

A. Equipment and materials shall be protected from theft, injury or damage.

B. Protect conduit openings with temporary plugs or caps.

C. Provide adequate storage for all equipment and materials delivered to the job site. Location of the space will be designated by the Owner's representative or Architect/Engineer. Equipment set in place in unprotected areas must be provided with temporary protection.

D. Provide protection of all energized equipment during installation and construction.

3.13 EXTRA WORK

A. For any extra electrical work which may be proposed, this Contractor shall furnish to the Construction Manager, an itemized breakdown of the estimated cost of the materials and labor required to complete this work. Proceed only after receiving a written order from the Construction Manager establishing the agreed price and describing the work to be done. Prior to any extra work which may be proposed, submit unit prices (same prices for increase/decrease of work) for the following items:

1. 1/2", 3/4", 1", 1-1/2" conduit;
2. #12, #10, #8, #6, #2 wire;
3. Receptacles,
4. GFCI receptacle,
5. Data or network box,
6. Fire alarm devices,
7. Clock.
8. Light Fixtures by type.
9. Motor control devices

3.14 DRAWINGS AND MEASUREMENTS

A. These Specifications and accompanying Drawings are intended to describe and provide for finished work. They are intended to be cooperative, and what is called for by either shall be as binding as if called for by both. The Contractor understands that the work herein described shall be complete in every detail.

B. The Drawings are not intended to be scaled for rough-in measurements or to serve as Shop Drawings. Field measurements necessary for ordering materials and fitting the installation to the building construction and arrangement are the Contractor’s responsibility.

END OF SECTION

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SECTION 26 05 24

CONDUIT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Conduit, fittings and conduit bodies.

1.02 REFERENCE STANDARDS

A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC); 2005.

B. ANSI C80.3 - American National Standard for Steel Electrical Metallic Tubing (EMT); 2005.

C. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.

D. NECA 101 - Standard for Installing Steel Conduit (Rigid, IMC, EMT); National Electrical Contractors Association; 2006.

E. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; National Electrical Manufacturers Association; 2007.

F. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Tubing and Conduit; National Electrical Manufacturers Association; 2003.

G. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing; National Electrical Manufacturers Association; 2004.

H. NFPA 70 - National Electrical Code; National Fire Protection Association; 2014.

1.03 SUBMITTALS

A. Product Data: Provide for metallic conduit, flexible metal conduit, liquidtight flexible metal conduit, metallic tubing, nonmetallic conduit, flexible nonmetallic conduit, nonmetallic tubing, fittings, and conduit bodies.

B. Buy America Act Certification: Submit documentation certifying that products comply with provisions of the Buy America Act.

1.04 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for purpose specified and shown.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Accept conduit on site. Inspect for damage.

B. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering. Store indoor if possible. If stored outdoor, store off of ground, and in such a way to provide air circulation and allow water to drain off.

C. Protect PVC conduit from sunlight.

1.06 STANDARDS

A. Buy America – U.S. Department of Transportation Requirements: The contractor agrees to comply with 49 U.S.C. § 5323(j), as amended by MAP-21 and 49 C.F.R. part 661, to the extent consistent with MAP-21, and subsequent amendments to those regulations that may be promulgated. The Contractor also agrees to comply with FTA directives to the extent those directives are consistent with MAP-21, except to the extent that FTA determines otherwise in writing. Buy America requirements state that Federal funds may not be obligated unless steel, iron, and manufactured products used in FTA-funded projects are produced in the United States, unless a waiver has been granted by FTA or the product is subject to a general waiver. General waiver requirements are listed in 49 CFR 661.7.

PART 2 - PRODUCTS

2.01 CONDUIT REQUIREMENTS

A. Conduit Size: Comply with NFPA 70.

1. Minimum Size: 1/2 inch above ground, unless otherwise specified.

B. Underground Installations:

1. Direct burial within 5 Feet from Foundation Wall: Use PVC schedule 40.
2. In slab or concrete encased: Use Type EB-35 duct, type DB-60 duct, or PVC Schedule 40.

3. Minimum Size: Direct buried - 1 inch.
4. Maximum Size in Slab: 3/4 inch.

C. Outdoor Locations, Exposed Above Grade:

1. Use rigid steel conduit, or intermediate metal conduit.
2. Use PVC-coated rigid conduit at locations where conduit enters exposed outside concrete. Extend use of PVC-coated rigid conduit at least 6 inches above the concrete and at least 6 inches below the concrete.

D. Indoor Locations:

1. Use electrical metallic tubing in all applications, except as otherwise specified or indicated. Provide intermediate metal conduit below 10' AFF in high bay area.

2. Concealed: Use EMT, or intermediate metal conduit.

3. Above Suspended Ceilings: Use electrical metallic tubing. The use of flexible metallic conduit for service to individual recessed light fixture is acceptable.

E. Damp and Humid Locations: Use rigid galvanized steel conduit or PVC SCH 40 where permitted by the CODE.

2.02 STEEL CONDUIT AND TUBING

A. Manufacturers:

1. Allied Tube & Conduit: www.alliedtube.com.
2. Wheatland Tube Company: www.wheatland.com.
3. Western Tube & Conduit Co.: www.westerntube.com.

B. Rigid Metal Conduit: Federal Specification WWC581D, ANSI C80.1, UL-listed, threaded, hot-dip galvanized conduit. Electro-plate conduit is not acceptable.

C. Intermediate Metal Conduit (IMC): Federal Specification WWC581, UL-1242, hot-dipped galvanized inside and out. Electro-plate conduit is not acceptable.

D. Fittings (Couplings, Bushings, etc.): Cast malleable iron, galvanized or cadmium plated fittings conforming to Federal Specification WF408. Copper-free aluminum fittings are not acceptable. Provide compression fittings for all conduit types.

1. Manufacturers:

a. Appleton: www.appletonelec.com
b. Cooper/Crouse-hinds: www.crouse-hinds.com
c. Thomas & Betts Corporation: www.tnb.com

E. Conduit Bodies (Rigid Steel and IMC, JBs, T, etc.): Threaded hub, malleable iron body and cover, with captive stainless steel screws, UL Standard 514.

1. Manufacturers:

a. Appleton: www.appletonelec.com
b. Cooper/Crouse-Hinds.: www.crouse-hinds.com
c. Hubbell/Killark: www.hubbell.com

2. Use mogul units for conduit sizes larger than 2 inches.

2.03 PVC COATED METAL CONDUIT

A. Manufacturers:

1. Allied Tube & Conduit: www.alliedtube.com.
2. Thomas & Betts Corporation: www.tnb.com.
3. Robroy Industries: www.robroy.com.

B. Description: Federal Specification WWWC581E, ANSI Specification C80.1 and UL 6, hot-dipped galvanized inside and outside, including threads. PVC exterior coating 40 mils normal thickness. Interior urethane coating of 2 mils.

C. Fittings and Conduit Bodies: External PVC coating to match conduit.

2.04 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Manufacturers:

1. AFC Cable Systems, Inc.: www.afcweb.com.
2. Electri-Flex Company: www.electriflex.com.
3. International Metal Hose: www.metalhose.com.

B. Description: Interlocked flexible galvanized steel construction with liquid-tight PVC jacket, conforming to Federal Specification WF406 and UL 360.

C. Fittings: Malleable iron, cadmium-plated fittings with compression type steel ferrule, and neoprene gasket sealing rings with insulated throat, conforming to UL 514B.

2.05 ELECTRICAL METALLIC TUBING (EMT)

A. Manufacturers:

1. Allied Tube & Conduit: www.alliedtube.com.
2. Wheatland Tube Company: www.wheatland.com.
3. Western Tube & Conduit Co.: www.westerntube.com.

B. Description: Labeled, mild steel electrically welded, galvanized thin-wall conduit complying with NEC requirements, produced in accordance with ANSI C80.3, UL 797, and Federal Specification WWC653.

C. Fittings: ANSI/NEMA FB 1; steel or malleable iron, compression type.

1. Manufacturers:

a. Appleton: www.appletonelec.com
b. Cooper Crouse-Hinds: www.crouse-hinds.com
c. Thomas & Betts Corporation: www.tnb.com

2.06 NONMETALLIC CONDUIT

A. Manufacturers:

1. AFC Cable Systems, Inc.: www.afcweb.com.
2. Electri-Flex Company: www.electriflex.com.
3. Carlon Electrical Products: www.carlon.com.

B. Conduit Description: Polyvinyl Chloride (PVC) Conduit shall be schedule 40 conforming to ASTM D-1784, UL 651, and NEMA TC 2 rated for use with 90 degree C conductors. PVC shall be sunlight resistant.

C. Plastic Duct Description: Type DB-60 (NEMA TC-6) or EB-35 (NEMA TC-8), conforming to ASTM D-1784 and ASTM F-51. Duct shall be rated for use in underground concrete-encased ductbank.

D. PVC Conduit Fittings and Conduit Bodies: NEMA TC 3, and UL 651.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify routing and termination locations of conduit prior to rough-in.

B. In general, conduit routing is not shown on drawings. Conduit routing, when shown on drawings, is diagrammatic indicating approximate locations unless dimensioned.

3.02 INSTALLATION

A. Install conduit securely, in a neat and workmanlike manner, specified in NECA.

B. Install steel conduit as specified in NECA 101.

C. Install nonmetallic conduit in accordance with manufacturer's instructions.

D. Arrange supports to prevent misalignment during wiring installation.

E. Support conduit using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.

F. Group related conduits; support using conduit rack. Construct rack using steel channel; provide space on each for 25 percent additional conduits.

G. Fasten conduit supports to building structure and surfaces using approved methods, fasteners, and miscellaneous support devices.

H. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.

I. Do not attach conduit to ceiling support wires.

J. Arrange conduit to maintain headroom and present neat appearance.

K. Route exposed conduit parallel and perpendicular to walls.

L. Route conduit installed above accessible ceilings parallel and perpendicular to walls.

M. Route conduit in and under slab from point-to-point.

N. Maintain adequate clearance between conduit and piping.

O. Cut conduit square using saw or pipecutter; de-burr cut ends.

P. Bring conduit to shoulder of fittings; fasten securely.

Q. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.

R. Use conduit hubs or sealing locknuts to fasten conduit to sheet metal boxes in damp and wet locations.

S. Install no more than equivalent of three 90 degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic one shot bender to fabricate bends in metal conduit larger than 2 inch size.

T. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.

U. Provide suitable fittings to accommodate expansion and deflection where conduit crosses control and expansion joints.

V. Provide suitable pull string in each empty conduit except sleeves and nipples.

W. Use suitable caps to protect installed conduit against entrance of dirt and moisture.

X. Ground and bond conduit under provisions of Section 26 05 26.

3.03 INTERFACE WITH OTHER PRODUCTS

A. Firestop all conduit penetrations of rated walls, floors, etc., using UL approved methods including walls surrounding the fine screen room.

B. Route conduit through roof openings for piping and ductwork wherever possible. Where separate roofing penetration is required, coordinate location and installation method with roofing installation.

END OF SECTION

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SECTION 26 05 19

BUILDING WIRE AND CABLE

PART 1 - GENERAL

1.01 SCOPE

A. Work covered by this section includes furnishing all labor, equipment, and materials required to install, connect, and test all wire and cable, including splices, terminations, connectors, and accessories for a complete installation as shown on the drawings and/or specified herein.

B. The Contractor's attention is directed to the fact that all wires and cables are not necessarily shown on the Drawings, which are more or less schematic. However, the Contractor shall be responsible for furnishing and installing all wire and cable indicated or required to properly connect and place into operation all equipment and services requiring such wiring and/or cable.

C. Scope include process control wiring as defined by the drawings and by the equipment supplier’s shop drawings.

1.02 QUALITY ASSURANCE

A. Samples of all wire and cable, clearly marked and long enough to show complete identification, shall be submitted to the office of the Engineer for approval prior to wiring installation.

B. No defective or damaged wire and cable shall be incorporated into the work.

1.03 SIZING OF CONDUCTORS

A. Unless otherwise required or directed by the Engineer, conductors shall be furnished in the sizes shown on the Drawings. No wire for lighting, power, or motor control circuits shall be smaller than No. 12 AWG. Switch legs for lighting circuits carrying less than eight amps may be No. 14 AWG. No wire for instrumentation and low-level signal transmission pairs shall be smaller than No. 16 AWG for single pairs or No. 18 AWG for bundled cable.

B. All wires and cables shall be of such size as to conform to the regulations of the current edition of the National Electrical Code for current carrying capacity where such regulations apply. Where such regulations do not apply, the wires and cables shall be of such size as to operate at a temperature which is safe for the insulation used, and the size shall be subject to the approval of the Engineer.

C. Where the size of lighting wiring is not given on the Drawings, it shall be of such size that the voltage drop from the main panel to the lighting panel is not more than one percent, and the drop in the branch circuit is not more than two percent. The voltage drop in motor feeder, when the wire size is not specified, shall not be more than three percent at full load from the Motor Control Center to the motor terminal.

1.04 SHOP DRAWINGS AND ENGINEERING DATA

A. Complete shop drawings and engineering data shall be submitted in accordance with requirements of the section entitled "Shop Drawings, Product Data and Samples" of these Specifications.

1.05 STORAGE AND PROTECTION

A. Store and protect all wire and cable in accordance with the manufacturer's recommendations and requirements of the section entitled "General Equipment Stipulations" of these Specifications.

B. Wire and cable shall be stored indoors in a dry and warm location and in its original packaging.

1.06 GUARANTEE

A. Provide a guarantee against defective materials and workmanship in accordance with requirements of the section entitled "Warranties and Bonds" of these Specifications.

1.07 SUBMITTALS

A. Buy America Act Certification: Submit documentation certifying that products comply with provisions of the Buy America Act.

1.08 STANDARDS

A. Buy America – U.S. Department of Transportation Requirements: The contractor agrees to comply with 49 U.S.C. § 5323(j), as amended by MAP-21 and 49 C.F.R. part 661, to the extent consistent with MAP-21, and subsequent amendments to those regulations that may be promulgated. The Contractor also agrees to comply with FTA directives to the extent those directives are consistent with MAP-21, except to the extent that FTA determines otherwise in writing. Buy America requirements state that Federal funds may not be obligated unless steel, iron, and manufactured products used in FTA-funded projects are produced in the United States,

unless a waiver has been granted by FTA or the product is subject to a general waiver. General waiver requirements are listed in 49 CFR 661.7.

PART 2 - PRODUCTS

2.01 CONDUCTORS – GENERAL

A. Conductors shall be solid or Class B concentric stranded, soft or annealed, uncoated copper free from kinks and defects in accordance with ASTM B 3 or B 8.

B. Conductors should have a conductivity not less than 97 percent.

C. The wire and cable shall have size, grade of insulation, voltage, and manufacturer's "E-Number" permanently marked on the outer covering at not more than two-foot intervals.

D. All wires shall conform to the latest Standards of the ASTM and IPCEA and shall be tested for their full length by these Standards.

E. Insulation thickness shall be not less than that specified by the National Electrical Code.

F. All control circuit wiring and all wiring No. 8 AWG and larger shall be stranded. Lighting branch circuits No. 12 and No. 10 AWG may be solid. Wiring shall be stranded as follows:

1. No. 14 through No. 2 AWG shall have a minimum of 7 strands.
2. No. 1 through No. 4/0 AWG shall have a minimum of 19 strands.
3. No. 250 MCM through No. 500 MCM shall have a minimum of 37 strands.

G. All circuits except control and instrumentation circuits shall have a separate grounding conductor carried in the conduit.

2.02 CONDUCTORS FOR WIRE AND CABLE

A. For service entrance, motor branch, and feeder circuits operating at 480/277 volts, the conductors shall be single-conductor, cable rated, 600 volts. The single-conductor cable shall consist of uncoated annealed copper, Class B stranded per ASTM B 8 and insulated with corona, ozone, heat and moisture resisting cross-linked polyethylene insulation rated to withstand a copper temperature of 90 °C, Underwriter's approved Type XHHW-2 and shall be as manufactured by Southwire, General Cable Corporation, Okonite Company or equal.

B. For general lighting and receptacle branch circuits operating at 120, 208 and 277 volts, the conductor shall be single-conductor cable rated 600 volts. The single-conductor cable shall be uncoated annealed copper. No. 12 and No. 10 AWG may be solid, or stranded; larger cables shall be stranded per ASTM B 8 and insulated with polyvinyl chloride insulation rated to withstand a copper temperature of 75 °C, Underwriter's approved Type THWN/THHN, and shall be as manufactured by Southwire, General Cable Corporation, Okonite Company, or equal.

C. For lighting fixture drop wire or for running in fluorescent units, the conductors shall be single-conductor cable rated 600 volts. The single-conductor cable shall be stranded tinned copper with a 31-mil-thick wall silicone insulation and a glass braid jacket overall rated to withstand a copper temperature of 150 °C, Underwriter's approved silicone insulated fixture wire type SFF-2, and shall be as manufactured by General Cable Corporation, General Electric Company, or equal.

D. For control circuits the conductors may be single or multi-conductor cable rated 600 volts. The conductors shall consist of uncoated annealed copper Class B stranded per ASTM B 8 and shall be No. 14 or No. 12 AWG, 7-strand, identified at each end using Brady wire markers B-500 vinyl cloth, Thomas and Betts "E-Z Code" wire markers, or equal.

1. Single-conductor cable shall have color red, to withstand a copper temperature of 90°C, Underwriter's Laboratories approved Type XHHW, and shall be as manufactured by General Electric Company, Phelps Dodge, General Cable, Okonite, or equal.
2. Multi-conductor cable shall consist of single-conductor cables rated 600 volts and insulated to withstand a copper temperature of 90°C cabled together to form a cable assembly which is Underwriter's Laboratories approved for installation in conduit. The core shall be color coded in accordance with IPCEA, Method 1, with a plastic tape cover and a PVC or neoprene jacket overall.
3. Where shown on the cable schedule, Single-conductor cable shall have 45-mil-thick wall of cross-linked polyethylene or polyvinyl chloride insulation, color red, to withstand a copper temperature of 90 □C, Underwriter's Laboratories approved Type RHH-RHW, and shall be as manufactured by General Electric Company, Phelps Dodge, General Cable, Okonite, or equal.

E. Bare grounding conductor shall be Class A or B medium hard drawn, high conductivity bare copper, sized as shown on the Drawings. Conductors No. 6 AWG and smaller may be solid. Conductors No. 4 AWG and larger shall be stranded.

F. Flexible power cords shall be moisture-resistant, oil-resistant, neoprene-sheathed service cable designed for extra hard usage, Type SO, rated 600 volts at 90°C continuous conductor temperature. Flexible heater cords shall be moisture-resistant, oil-resistant, neoprene and cotton sheathed service cable designed for extra hard usage, Type HSO, rated 600 volts at 90°C continuous. Insulation shall be thermoplastic ethylene-propylene conforming to IPCEA S-68-516. Neoprene shall conform to ASTM D 752. All flexible cords shall be UL listed.

2.03 INSTRUMENTATION WIRING

A. Instrumentation and low level DC signal wiring shall be shielded, twisted pair conductors. Single twisted pairs shall consist of two Class B stranded, No. 16 AWG annealed copper conductors, one white and one black, with 15 mils of PVC insulation rated for 300 volts and 90°C minimum continuous conductor temperature. Pairs shall be twisted to a lay of 1.5 to 2.5 inches. A 0.35 mil by 0.50 mil aluminum-mylar tape shield with stranded, bare No. 18 AWG, tinned copper drain wire in contact with the aluminum side of the shield shall be applied helically around the twisted pair. An overall jacket of 90°C black PVC at least 30 mils in thickness shall be applied to the outside. Shield coverage shall be full 100 percent. All instrumentation wiring shall be UL listed.

B. Bundled pair cable shall consist of multiple, individually shielded, numbered twisted pairs as described above except that conductors and individual shield drain wires shall be No. 20 AWG and No. 22 AWG, respectively. Cable bundle shall include a stranded, No. 22 AWG, copper communication wire with 15 mil PVC insulation continuously rated for 90°C. Flame-retardant, non-wicking fillers shall be provided for rounding out cable. Bundled core shall be wrapped in a 2.35-mil aluminum mylar tape shield with a bare, stranded No. 20 AWG tinned-copper drain wire applied helically to the outside of the bundle. Cable assembly shall be jacketed with a minimum 50 mil thick black PVC jacket rated for a continuous temperature of not less than 90°C. A rip cord shall be provided under the jacket for stripping. Instrumentation cable shall conform to the requirements of IPCEA S-61-402.

2.04 SPLICES AND TERMINATIONS

A. Splices, taps and attachment of fittings and lugs shall be electrically and mechanically secure, and approved solderless lugs and connectors shall be used. Lugs and connectors shall be top quality product of Burndy, O-Z, Thomas and Betts, or equal manufacturer. Conductors shall not bind at bushings. Lugs shall be of the correct sizes for the conductors joined and strands shall not be cut from a conductor.

B. Splices, taps, and terminations of cable rated 600 volts and less requiring tape shall be half lap and at least 3 layers. Taping shall be neatly done and form a

permanent insulation equal in mechanical and electrical strength to the insulation of the conductor. Taping shall be as follows:

1. Rubber Insulation:
2. Inner Layer: Okonite Rubber Tape, 3M "Scotchfil" Electrical Insulation Putty, Plymouth "Plysafe" Tape, or equal.
3. Outer Layer: 3M "Scotch No. 88" Tape, Permacel No. 295 Tape, Slipknot Grey Tape, or equal.
4. Thermoplastic Insulation: 3M "Scotch No. 88" Tape, Permacel No. 295 Tape, Slipknot Grey Tape, or equal.
5. Terminations at motor junction boxes shall be sealed with 3M "Scotchkote" Electrical Coating over the outer layer of tape. All splices 600 volts and less in No. 8 AWG and larger sizes shall be made using approved bolted connectors properly taped as specified herein.

C. For No. 10 AWG and smaller branch circuit and fixture conductors operating at 277 volts or less, live spring pressure connectors rated for 600 volts may be used for splices and junctions. When installed in a fixture, connectors shall be rated for 1,000 volts.

D. All splices below grade shall be watertight utilizing epoxy filled splicing kits.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All interconnecting wiring shall be run overhead or installed in approved conduit or cable trays and connected as shown on the Drawings and/or specified herein. Unless otherwise shown or specified, all wiring shall be run in conduit.

B. Unless otherwise shown on the Drawings, wiring shall be run by the most direct route keeping overall circuit length to a minimum.

C. Instrumentation and low level signal wiring shall not be located in the same conduit as motor wiring, feeder wiring, branch circuit wiring, or control wiring. Control wiring shall not be located in the same conduit as feeder wiring, or instrumentation wiring.

D. All control and circuit wiring in cabinets, boxes, gutters, etc. shall be neatly tied and held using nylon cable ties and mounting brackets.

E. After installation, conductors shall not have dents, scars, cuts, pressure indentations, abraded areas, etc.

F. Conductors 600 volts and below shall not be bent to a radius less than 12 times the cable diameter. Conductors above 600 volts shall not be bent to a radius of not less than 24 times the cable diameter.

G. Wiring run in metallic conduits shall be arranged such that there are an equal number of conductors of each phase in each conduit. Under no circumstances shall metallic conduits contain one single conductor or several conductors of only one phase. This requirement shall not apply to single, bare grounding conductors run in conduit to grounding rods or grids.

H. Conductors may be coated with talc, soapstone, Ideal "Yellow 77" or "Wire Lube", Electro-Compound "Y-ER EAS," or equal, to facilitate pulling into raceways, but in no case may they be greased or coated with any substance injurious to conductor insulation and jacket. Pulling tension shall be exerted primarily on the strongest component of conductors, normally the metallic conductors themselves and not on the insulation jacket. When installing cable in conduit with pulling eye attached to copper conductor, the tension shall not exceed 0.008 pound per circular mil area of the conductor or 5,000 pounds, whichever is smaller. When a basket grip is used over the outer jacket of the cable, the maximum pulling tension shall not exceed 0.008 pound per circular mil area of the conductor or 1,000 pounds, whichever is smaller. In no case shall pulling tensions recommended by the wire manufacturer be exceeded. The maximum sidewall pressure exerted on the insulation and sheath at a cable bend shall not exceed 300 pounds per foot of conduit bending radius. Conductors shall not be pulled "through" any outlet, conduit or box. Separate "pulls" shall be made on each side of such point.

I. Unless otherwise specified, splices shall be made at outlet or conduit boxes, pull or junction boxes, manholes, or vaults. No splice shall be drawn into a conduit. Splices in wiring rated 600 volts and below shall be made with enough spare wire for two splices to be remade with the wire at the same location.

J. All instrumentation and thermocouple extension wire shields shall be grounded. Shields on individual circuits shall be electrically continuous and shall be grounded at only 1 point in the circuit. Shields on thermocouple extension wire shall be grounded at the thermocouple only.

K. Until conductors rated above 600 volts are terminated, they shall be kept sealed to prevent entrance of moisture into cable structure. Do not terminate cable if ambient relative humidity in working space is above 70 percent.

L. Lightning arrestors shall be installed with the shortest line lead possible, but in no case longer than 18 inches.

M. When conductors, or cables, are directly buried without concrete encasement, install permanently colored polyethylene, 0.004-inch film, marking tape, 6 inches

wide, and at 6 inches below finished grade. Direct buried conductors or cables installed under roadways and paved areas shall be installed in minimum 1-inch-diameter rigid steel conduit.

N. Inside all manholes, all cables are to have racks with insulator supports. Supports are to be within 6 inches of each side of a splice and spaced not farther than three feet apart.

O. All conductors are to be identified. Branch circuits, motor feeders, and lightning wiring shall be identified by color coding as follows:

	277/480/4160V	120/208/240V
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	Blue
Neutral	Grey	White
Ground	Bare	Bare or Green

The color coding on No. 8 AWG and smaller conductors shall be continuous in length. No taping, painting or other means of coding will be acceptable. Conductors No. 6 AWG and larger and conductors operating above 600 volts shall be black with color coded tape visible at each point of access or view.

P. Conductors used for temporary construction power shall not be used for the permanent installation, and the permanent conductor system shall not be used for construction power unless authorized in writing by the Engineer. Circuit protective devices shall never be temporarily bypassed.

3.02 FIELD TESTS

A. All low voltage cables installed under this contract shall be meggered to verify insulation integrity.

B. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner.

C. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment.

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SECTION 26 05 26

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 and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned 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.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Plans showing as-built, dimensioned 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.

b. Instructions for periodic testing and inspection of grounding features at test wells, grounding connections for separately derived systems based on NFPA 70B.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

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

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.

3. Fushi Copperweld Inc.
4. Galvan Industries, Inc.; Electrical Products Division, LLC.
5. ILSCO.
6. Siemens Power Transmission & Distribution, Inc.
7. Or Engineer Approved equal.

2.3 CONDUCTORS

A. Insulated Conductors: **Copper or tinned-copper** wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

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. 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 and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 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. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

H. Conduit Hubs: Mechanical type, terminal with threaded hub.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

K. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

N. Straps: Solid copper, cast-bronze clamp or copper lugs. Rated for 600 A.

O. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one or two-piece clamp as required.

P. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

Q. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.

    a. Material: Die-cast zinc alloy.
    b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad 3/4 inch by 10 feet (19 mm by 3 m).

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.

C. Ground Plates: 1/4 inch (6 mm) thick, hot-dip galvanized.

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 equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, 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; 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 AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 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.

3.5 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.

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. 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.

H. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare, tinned copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6 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 shall be at least 12 inches (300 mm) deep, with cover.

1. 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 as indicated, extending around the perimeter of building

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. Concrete-Encased Grounding Electrode (Ufer Ground): 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.

K. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet (6.0 m) long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

3.7 FIELD QUALITY CONTROL

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

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

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. 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.

F. Grounding system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. 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: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

I. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Boxes, enclosures, and cabinets.

1.03 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

C. EMT: Electro-Metallic Tubing

1.04 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

PART 2 - PRODUCTS

2.01 METAL CONDUITS, TUBING, 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. Allied Tube & Conduit.
2. Anamet Electrical, Inc.
3. Electri-Flex Company.
4. Republic Conduit.
5. Southwire Company.
6. Thomas & Betts Corporation.
7. Western Tube and Conduit Corporation.
8. Wheatland Tube Company.

9. Or Engineer Approved equal.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Fittings for EMT:

a. Material: Steel.
b. Type: Compression.

2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

H. Joint Compound for IMC, or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 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.
6. Hubbell Incorporated.
7. RACO; Hubbell.
8. Thomas & Betts Corporation.
9. Wiremold / Legrand.
10. Or Engineer Approved equal.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

F. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

G. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

H. Gangable boxes are allowed.

I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

J. 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.

PART 3 - EXECUTION

3.01 RACEWAY APPLICATION

A. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.

2. Exposed, Not Subject to Severe Physical Damage: EMT, RNC identified for such use.

3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:

a. Warehouse areas within 10 feet of floor.

b. Traffic areas of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.

5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.

6. Damp or Wet Locations: GRC.

7. 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 Raceway Size: 1/2-inch trade size, unless otherwise noted on drawings.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.

2. 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 compression, steel fittings. Comply with NEMA FB 2.10.

4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

3.02 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Complete raceway installation before starting conductor installation.

C. Comply with NEC requirements for hangers and supports.

D. Install no more than the equivalent of three 90-degree bends in any conduit run. Support within 12 inches of changes in direction.

E. Install conduits parallel or perpendicular to building lines.

F. Support conduit within 12 inches of enclosures to which attached.

G. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.

2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

H. Threaded Conduit Joints: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

I. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

J. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

K. 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.

L. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

M. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

N. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.

2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

O. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

P. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Q. 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 top of box unless otherwise indicated.

R. 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.

S. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

T. Set metal floor boxes level and flush with finished floor surface.

3.03 IDENTIFICATION

A. Stamped stainless steel tag: Conduit tags shall be permanently attached to each exposed end of conduit runs such as in manholes, pull boxes, panels, junction boxes, etc., and at each point of entry into the building. Each tag shall be stamped with the appropriate conduit number

3.04 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior wall assemblies.

3.05 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies.

3.06 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 37

BOXES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Wall and ceiling outlet boxes.

B. Pull and junction boxes.

1.02 REFERENCE STANDARDS

A. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.

B. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports; National Electrical Manufacturers Association; 2003.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association; 2003.

D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2014.

1.03 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Products: Provide products listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.04 SUBMITTALS

A. Buy America Act Certification: Submit documentation certifying that products comply with provisions of the Buy America Act.

1.05 STANDARDS

A. Buy America – U.S. Department of Transportation Requirements: The contractor agrees to comply with 49 U.S.C. § 5323(j), as amended by MAP-21 and 49 C.F.R. part 661, to the extent consistent with MAP-21, and subsequent amendments to those regulations that may be promulgated. The Contractor also agrees to comply with FTA directives to the extent those directives are consistent with MAP-21, except to the extent that FTA determines otherwise in writing. Buy America requirements state that

Federal funds may not be obligated unless steel, iron, and manufactured products used in FTA-funded projects are produced in the United States, unless a waiver has been granted by FTA or the product is subject to a general waiver. General waiver requirements are listed in 49 CFR 661.7.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Appleton Electric: www.appletonelec.com.

B. Arc-Co./Division of Arcade Technology: www.arc-co.com.

C. Unity Manufacturing: www.unitymfg.com.

2.02 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1, galvanized steel.

1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 1/2 inch male fixture studs where required.

2.03 PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: NEMA OS 1, galvanized steel.

B. Surface Mounted Cast Metal Box: NEMA 250, Type 4; flat-flanged, surface mounted junction box:

1. Material: Galvanized cast iron.
2. Cover: Furnish with ground flange, neoprene gasket, and stainless steel cover screws.

C. Fiberglass Handholes: Die molded glass fiber hand holes:

1. Cable Entrance: Pre-cut 6 x 6 inch cable entrance at center bottom of each side.
2. Cover: Glass fiber weatherproof cover with nonskid finish.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify locations of outlets in offices and work areas prior to rough-in.

3.02 INSTALLATION

A. Install boxes securely, in a neat and workmanlike manner, as specified in NECA 1.

B. Install in locations as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and as required by NFPA 70.

C. Set wall mounted boxes at elevations to accommodate mounting heights specified in section for outlet device.

D. Electrical boxes are shown on Drawings in approximate locations unless dimensioned.

E. Orient boxes to accommodate wiring devices oriented as specified in Section 26 27 26.

F. Maintain headroom and present neat mechanical appearance.

G. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.

H. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed luminaire. Coordinate with other trades locate access panels allowing access for all trades.

I. Do not install boxes in fire resistance rated partitions and other elements, using materials and methods shown on the drawings.

J. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

K. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.

L. Use flush mounting outlet box in finished areas.

M. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.

N. Do not install flush mounting box back-to-back in walls; provide minimum 6 inches separation. Provide minimum 24 inches separation in acoustic rated walls.

O. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

P. Use stamped steel bridges to fasten flush mounting outlet box between studs.

Q. Use adjustable steel channel fasteners for hung ceiling outlet box.

R. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12 inches of box.

S. Use gang box where more than one device is mounted together. Do not use sectional box.

T. Use cast outlet box in exterior locations exposed to the weather and wet locations.

U. Large Pull Boxes: Use hinged enclosure in interior dry locations, surface-mounted cast metal box in other locations.

3.03 ADJUSTING

A. Adjust flush-mounting outlets to make front flush with finished wall material.

3.04 CLEANING

A. Clean interior of boxes to remove dust, debris, and other material.

B. Clean exposed surfaces and restore finish.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Nameplates and labels.

B. Wire and cable markers.

C. Conduit markers.

1.02 REFERENCE STANDARDS

A. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.03 SUBMITTALS

A. Product Data: Provide catalog data for nameplates, labels, and markers.

1.04 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Brady Corporation: www.bradycorp.com.

B. Seton Identification Products: www.seton.com/aec.

C. HellermannTyton: www.hellermanntyton.com.

2.02 NAMEPLATES AND LABELS

A. Nameplates: Permanent engraved three-layer laminated plastic, white letters on black background. Wording to be approved by Architect.

B. Locations:

1. Each power panel, lighting panel, motor starter, safety disconnect switch, and control equipment enclosure.

2. Communication cabinets.

C. Letter Size:

1. Use 1/8 inch letters for identifying individual equipment and loads.

2. Use 1/4 inch letters for identifying grouped equipment and loads.

D. Labels: Embossed adhesive tape, with 3/16 inch white letters on black background. Use only for identification of individual wall switches and receptacles, and control device stations.

2.03 WIRE MARKERS

A. Description: tape, split sleeve, or tubing type wire markers.

B. Locations: Each conductor at panelboard gutters, pull boxes, outlet boxes, and junction boxes each load connection.

C. Legend:

1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.

2.04 CONDUIT MARKERS

A. Description: Stamped stainless steel tag. Conduit tags shall be permanently attached to each exposed end of conduit runs such as in manholes, pull boxes, panels, junction boxes, etc., and at each point of entry into the building. Each tag shall be stamped with the appropriate conduit number.

2.05 UNDERGROUND WARNING TAPE

A. Description: 4 inch wide plastic tape, detectable type colored yellow with suitable warning legend describing buried electrical lines.

PART 3 - EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive nameplates and labels.

3.02 INSTALLATION

A. Install nameplates and labels parallel to equipment lines.

B. Secure nameplates to equipment front using screws.

C. Secure nameplates to inside surface of door on panelboard that is recessed in finished locations.

D. Identify underground conduits using underground warning tape. Install one tape per trench at 3 inches below finished grade.

END OF SECTION

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SECTION 26 05 59

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Conduit and equipment supports.

B. Anchors and fasteners.

1.02 REFERENCE STANDARDS

A. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.

B. NFPA 70 - National Electrical Code; National Fire Protection Association; 2014.

1.03 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.04 SUBMITTALS

A. Buy America Act Certification: Submit documentation certifying that products comply with provisions of the Buy America Act.

1.05 STANDARDS

A. Buy America – U.S. Department of Transportation Requirements: The contractor agrees to comply with 49 U.S.C. § 5323(j), as amended by MAP-21 and 49 C.F.R. part 661, to the extent consistent with MAP-21, and subsequent amendments to those regulations that may be promulgated. The Contractor also agrees to comply with FTA directives to the extent those directives are consistent with MAP-21, except to the extent that FTA determines otherwise in writing. Buy America requirements state that Federal funds may not be obligated unless steel, iron, and manufactured products used in FTA-funded projects are produced in the United States, unless a waiver has been granted by FTA or the product is subject to a general waiver. General waiver requirements are listed in 49 CFR 661.7.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Hangers, Supports, Anchors, and Fasteners - General: Corrosion-resistant materials of size and type adequate to carry the loads of equipment and conduit, including weight of wire in conduit.

B. Supports: Fabricated of structural steel or formed steel members; galvanized.

C. Hanger Rod: Galvanized all-thread rod, not smaller than 3/8 inch diameter

D. Anchors and Fasteners:

1. Do not use powder-actuated anchors or spring clips.
2. Concrete Structural Elements: Use precast inserts, expansion anchors, or preset inserts.
3. Steel Structural Elements: Use beam clamps or welded fasteners.
4. Concrete Surfaces: Use self-drilling anchors or expansion anchors.
5. Hollow Masonry, Plaster, and Gypsum Board Partitions: Use toggle bolts or hollow wall fasteners.
6. Solid Masonry Walls: Use expansion anchors or preset inserts.
7. Sheet Metal: Use sheet metal screws.

E. Metal Building Components

1. Verify with the metal building supplier any fastener items or screws to be drilled into girts/purlins/metal columns prior to beginning installation.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install hangers and supports as required to adequately and securely support electrical system components, in a neat and workmanlike manner, as specified in NECA 1.

1. Do not fasten supports to pipes, ducts, mechanical equipment, other conduits, ceiling support grid or grid support wires.
2. Do not drill or cut structural members.
3. Arrange conduit to maintain headroom and present a neat appearance.

B. Individual Conduits:

1. Support individual conduits directly to structural steel with beam clamps.
2. Support individual horizontal conduits 1-1/2 inch or smaller in diameter to walls by means of one-hole, malleable iron straps with clamp back spacers.
3. Support individual horizontal conduits larger than 1-1/2 inch in diameter to walls by means of forged steel conduit strap for vertical runs.

C. Groups of Conduits:

1. Construct conduit racks using galvanized steel channel and provide space on each for 25 percent additional conduits.
2. Attach groups of conduits to structural steel with galvanized steel channel attached with beam clamps. Attach conduit to channel with pipe clamps.

D. Suspended Support:

1. Attach horizontally suspended, single conduit plumb with hanger rod. Attach threaded rod to concrete with anchors and to structural steel with beam clamps. Attach conduit to threaded rod with clamps.
2. Attach horizontally suspended groups of conduit plumb with galvanized steel channel suspended from overhead at each end using threaded rod. Attach threaded rod to concrete with anchors and to structural steel with beam clamps. Attach conduit to channel with pipe clamps.
3. Provide sufficient threading on hanger rods at each end to permit at least 2 inches of adjustment.

E. Install surface-mounted cabinets and panelboards with minimum of four anchors.

F. In wet and damp locations use steel channel supports to stand cabinets and panelboards 1 inch off wall.

G. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.

END OF SECTION

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SECTION 26 05 74

OVERCURRENT PROTECTIVE DEVICE COORDINATION AND ARC-FLASH STUDY

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Software Developer

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

2. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

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 unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and 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.

PART 2 - PRODUCTS

2.1 SOFTWARE DEVELOPERS

~~A.~~ Manufacturers: Subject to compliance with requirements, provide products by one of the following~~:~~
1. EASY Power Inc.
2. E-Tap
3. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study

F. Coordination Study
1. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
   a. To normal system low-voltage load buses where fault current is 10 kA or less.
   b. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
2. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
3. Transformer Primary Overcurrent Protective Devices:
   a. Device shall not operate in response to the following:
      1) Inrush current when first energized.
      2) Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   b. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   c. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
4. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
   a. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
5. Protective Device Evaluation:
   a. Evaluate equipment and protective devices and compare to short-circuit ratings.
   b. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
   c. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

d. Include in the report identification of any protective device applied outside its capacity.

G. Arc-Flash Study

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

C. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

D. Include low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

E. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

F. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.

G. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

H. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Electrical Survey Data: Gather and tabulate the following input data to support study.

1. Product Data for overcurrent protective devices specified in other 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. Obtain electrical power utility impedance at the service.

3. Power sources and ties.
4. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
5. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
6. Motor horsepower and NEMA MG 1 code letter designation.
7. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.4 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.
   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.5 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION

SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching and dimming controls.
4. Indoor occupancy and vacancy sensors.
5. Switchbox-mounted occupancy and vacancy sensors
6. High-bay occupancy and vacancy sensors.

B. Related Requirements:

1. Section 26 27 26 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Philips Lighting Controls.
6. Sensor Switch, Inc.

2.2 INDOOR OCCUPANCY AND VACANCY SENSORS

A. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Passive infrared and Ultrasonic: Dual technology.
3. Integrated power pack.
4. Hardwired connection to switch.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:

a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. 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.

11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.

B. Dual-Technology Type: Wall or Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

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.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet (110 square meters) when mounted 48 inches (1200 mm) above finished floor.

2.3 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection using hardwired connection.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
4. Switch Rating: Not less than 800-V LED load at 120 V.

B. Wall-Switch Sensor:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m).
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, dual circuit. SP, manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: White.
11. Faceplate: Color matched to switch.

2.4 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "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 Section 26 05 19 "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 Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

C. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

D. 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.

E. 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.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

B. Wiring within Enclosures: 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.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.6 SOFTWARE SERVICE AGREEMENT (If applicable)

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Power Distribution and Branch Circuit panelboards.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective 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.

1.04 INFORMATIONAL SUBMITTALS

A. Panelboard Schedules: For installation in panelboards.

1.05 MAINTENANCE MATERIAL SUBMITTALS

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

1. Keys: Two spares for each type of panelboard cabinet lock.

2. Circuit Breakers Including GFCI Type: Two spares for each panelboard.

1.06 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories 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 PB 1.

D. Comply with NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards. Store in cool dry place.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.08 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions:

1. Notify Engineer and Owner no fewer than two days in advance of proposed interruption of electric service.

2. Do not proceed with interruption of electric service without Engineer and Owner's written permission.

3. Coordinate with Duke Energy Progress for service changes.

1.09 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.

1.10 WARRANTY

A. Warranty: Manufacturer's standard form.

1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.
   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

4. Finishes:
   a. Panels and Trim: 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: Galvanized steel.

5. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

B. Incoming Mains Location: Top and bottom.

C. 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.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.

2. Main and Neutral Lugs: Mechanical type.

3. Ground Lugs and Bus-Configured Terminators: Mechanical type.

E. 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.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. 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.

H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.02 POWER 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:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.
4. Or Engineer Approved equal.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. 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.

2.03 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:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.
4. Or Engineer Approved equal.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices: Plug-in or Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.04 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:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.
4. Or Engineer Approved equal.

B. 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. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor 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: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to 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.

3.02 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mount top of trim 90 inches above finished floor unless otherwise indicated.

C. 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.

D. Install overcurrent protective devices and controllers not already factory installed.

E. Install filler plates in unused spaces.

F. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.03 IDENTIFICATION

A. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

B. Panelboard Nameplates: Label each panelboard with a nameplate. Nameplate shall be permanent engraved three-layer laminated plastic, white letters on blue background with 1/2 inch high text minimum. Nameplates are to be secured to panelboards using self-tapping stainless steel screws, sharp ends protected or rivets. Wording to be approved by Engineer.

3.04 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION

SECTION 26 27 13

ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes work to accommodate utility company revenue meters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electricity-metering equipment.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.
3. Wire Termination Diagrams and Schedules: Include 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. Differentiate between manufacturer-installed and field-installed wiring.
4. Include series-combination rating data for modular meter centers with main disconnect device.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of metering equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
2. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

1.7 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and utility-furnished components.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

A. Install metering accessories furnished by the utility company, complying with its requirements.

B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by the Utility.

1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725.

C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

D. Meter Sockets:

1. Comply with requirements of electrical-power utility company.
2. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

3. Comply with requirements of utility company for meter center.

    a. Comply with UL 67.

4. Housing: NEMA 250, Type 3R enclosure.
5. Meter Socket Rating: Coordinated with connected feeder circuit rating.
6. Minimum Short-Circuit Rating: 22,000 A symmetrical at rated voltage.
7. Steady-state and short-circuit current ratings shall have ratings that match connected circuit ratings.
8. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers and having an adjustable magnetic trip setting for circuit-breaker frame sizes of 250 A and larger. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers." Circuit breakers shall be operable from outside the enclosure to disconnect the unit. Configure cover so it can be opened only when the disconnect switch is open.

    a. Identification: Complying with requirements in Section 26 05 53 "Identification for Electrical Systems."
    b. Physical Protection: Tamper resistant, with hasp for padlock.

E. Comply with equipment installation requirements in NECA 1.

F. Install meters furnished by utility company. Install raceways and equipment according to utility company's written instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

G. Install modular meter center according to switchboard installation requirements in NECA 400.

H. Install arc-flash labels as required by NFPA 70.

I. Wiring Method:

1. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
2. Minimum conduit size shall be 1/2 inch (13 mm).

J. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

END OF SECTION

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SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Wall switches.

B. Wall dimmers/motion sensors.

C. Receptacles.

D. Device plates and decorative box covers.

A. Comply with UL 467 for grounding and bonding materials and equipment.

1.03 REFERENCE STANDARDS

A. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.

B. NEMA WD 1 - General Color Requirements for Wiring Devices; National Electrical Manufacturers Association; 1999 (R 2005).

C. NEMA WD 6 - Wiring Device -- Dimensional Requirements; National Electrical Manufacturers Association; 2002.

D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2014.

1.04 SUBMITTALS

A. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

B. Manufacturer's Installation Instructions.

C. Provide products listed and classified by Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Cooper Wiring Devices: www.cooperwiringdevices.com.

B. GE Industrial: www.geindustrial.com.

C. Leviton Manufacturing, Inc: www.leviton.com.

2.02 WALL SWITCHES

A. Wall Switches: Heavy Duty, AC only general-use snap switch, complying with NEMA WD 6 and WD 1.

1. Body and Handle: Grey plastic with toggle handle.

2. Ratings:

a. Voltage: 120 - 277 volts, AC.
b. Current: 20 amperes minimum.

B. Switch Types: Single pole, double pole, and 3-way.

2.03 WALL DIMMERS

A. Wall Dimmers: Semiconductor dimmer for incandescent lamps, Type as indicated on drawings, complying with NEMA WD 6 and WD 1.

1. Body and Handle: Grey plastic with linear slide.

2. Voltage: 120 volts.

3. Power Rating: 600 watts.

B. Accessory Wall Switches: Match dimmer appearance.

2.04 RECEPTACLES

A. Receptacles: Heavy duty, complying with NEMA WD 6 and WD 1.

1. Device Body: Grey plastic.

2. Configuration: NEMA WD 6, type as specified and indicated.

B. GFCI Receptacles: Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements. Grey plastic

Type	Amps	Volts	NEMA Type	Configuration	Color
Duplex receptacles in manufacturing and similar areas	20	125	5-20R	2P-3W	Gray
Duplex receptacles in offices and similar areas	20	125	5-20R	2P-3W	White
Single receptacle	20	125	5-20R	2P-3W	Gray
Single-twist-lock receptacle	20	125	L5-20R	2P-3W	Black
Single receptacle	30	125	5-30R	2P-3W	Black
Single twist-lock receptacle	20	125/250	14-20R	3P-4W	Black
Single twist-lock receptacle	20	250	L6-20R	2P-3W	Black
Single twist-lock receptacle	20	250	L15-20R	3P-4W	Black
Single twist-lock receptacle	30	250	L15-30	R3P-4W	Black
Switches in manufacturing and similar areas	20	277	NA	Single Pole	Gray
	20	277	NA	Double Pole	Gray
	20	277	NA	Three Way	Gray
	20	277	NA	Four Way	Gray
Switches in offices and similar areas	20	277	NA	Single Pole	W
Switches with pilot light	20	120	NA	Single Pole with Pilot Light	Red
	20	277	NA	Single Pole with Pilot Light	Red

Welding receptacles: shall be rated for 60 amp, 480 volt, 3 pole, 4 wire service with interlocking 60 amp, 3 pole disconnect switch, Russellstoll Cat. No. FCSRA 13-60 for use with No. 8418 plug or equal by Cooper Crouse Hinds.

2.05 WALL PLATES

A. Decorative Cover Plates: Smooth stainless steel.

B. Contractor shall carefully refer to room dimensions, door swings, and locations of other equipment on architectural, mechanical, and process drawings for location of receptacles and switches. In the event of discrepancy with electrical drawings, architectural drawings shall govern.

C. Receptacles shall be wired complete, including branch circuits from panelboards. Three-phase receptacles shall be connected the same to assure proper phase rotation for equipment connected thereto.

D. Increase size of receptacle boxes as required to accommodate larger devices such as ground fault circuit interrupter receptacles, etc.

E. Receptacles in manufacturing areas shall be installed in web of column unless specifically shown otherwise.

F. Mounting Heights

1. Switch and receptacle heights given below, or as shown on the drawings, are to bottom of box. In unfinished masonry walls, adjust height to next higher course. Unless specifically noted otherwise on drawings, dimensions to floor shall be as follows:

a.	Switch	4'-0"
b.	Receptacles in offices and similar areas	1'-6"
c.	Receptacles in manufacturing and similar areas	4'-0"

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that outlet boxes are installed at proper height.

B. Verify that wall openings are neatly cut and will be completely covered by wall plates.

C. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.02 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean debris from outlet boxes.

3.03 INSTALLATION

A. Install securely, in a neat and workmanlike manner, as specified in NECA 1.

B. Install devices plumb and level.

C. Install switches with OFF position down.

D. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.

E. Do not share neutral conductor on load side of dimmers.

F. Install receptacles with grounding pole on top.

G. Connect wiring device grounding terminal to outlet box with bonding jumper.

H. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

I. Connect wiring devices by wrapping conductor around screw terminal.

3.04 INTERFACE WITH OTHER PRODUCTS

A. Install wall switch 48 inches above finished floor.

B. Install convenience receptacle 18 inches above finished floor.

C. Install convenience receptacle 6 inches above counter.

D. Install dimmer 48 inches above finished floor.

E. Install telephone jack 18 inches above finished floor.

F. Coordinate the installation of wiring devices with underfloor duct service fittings provided under Section 26 05 40.

3.05 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify that each receptacle device is energized.

D. Test each receptacle device for proper polarity.

E. Test each GFCI receptacle device for proper operation.

3.06 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.07 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

SECTION 26 28 13

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 the following:

    a. Control circuits.
    b. Motor-control centers.
    c. Panelboards.
    d. Switchboards.
    e. Enclosed controllers.
    f. Enclosed switches.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, 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. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," Section 017823 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.

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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

1. UL CLASS L FUSES, TIME-DELAY OR NONTIME-DELAY, CURRENT-LIMITING, 601 TO 6000 AMPERES

a. Time-Delay

1) Bussman: Low Peak KRP-C (600V).
2) Ferraz Shawmut: Amp-Trap A4BY (600V).
3) Littelfuse: KLPC (600V).

b. Nontime-Delay

1) Bussman: Limitron KTU (600V).

2. UL CLASS RK1 FUSES, DUAL ELEMENT, TIME-DELAY OR NONTIME-DELAY, CURRENT-LIMITING, 1/10 TO 600 AMPERES

a. Bussman: Low Peak LPS-RK (600V), LPN-RK (250V).
b. Littelfuse: LLSRK (600V), LLNRK (250V).

3. UL CLASS RK1 FUSES, NONTIME-DELAY, CURRENT LIMITING 1/10 TO 600 AMPERES

a. Bussman: Limitron KTS-R (600V), KTN-R (250V).
b. Ferraz Shawmut Amp-Trap A6K (600V), A2K (250V).
c. Littelfuse: KLSR (600V), KLNR (250V).

4. UL CLASS RK5 FUSES, DUAL ELEMENT, TIME-DELAY, CURRENT-LIMITING, 1/10 TO 600 AMPERES

a. Bussman: Fusetron FRS-R (600V), FRN-R (250V).
b. Littelfuse: FLSR (600V), FLNR (250V).

5. CARTRIDGE FUSES

a. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
b. Type RK-1: 250 and 600-V, zero- to 600-A rating, 200 kAIC, time delay.
c. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting, time delay.
d. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting, time delay.
e. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
f. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.2 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with **15** percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 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. Service Entrance: Class RK1, fast acting.
2. Feeders: Class RK1 dual element

3. Large Motor Branch (601-4000 A): Class L, time delay.
4. Power Electronics Circuits: Class J, high speed.
5. Other Branch Circuits Class RK1, dual element
6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

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SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 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.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. 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. Provide in PDF and electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

A. ACCEPTABLE MANUFACTURERS

1. Square D
2. Cutler-Hammer
3. Allen-Bradley
4. GE
5. Siemens
6. Or as approved by the Engineer.

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. 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.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

A. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 240 or 600-V ac as indicated
4. 1200 A and smaller
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. 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, 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. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

A. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, 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. Service-Rated Switches: Labeled for use as service equipment.

2.5 RECEPTACLE SWITCHES

A. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: 240 or 600-V ac, 30A; 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.

B. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusible Switch: 240 or 600-V ac, 30, 60, 100 A as indicated; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. 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.

D. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

E. 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, 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. Contact rating – as required by the equipment control.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.6 MOLDED-CASE CIRCUIT BREAKERS

A. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

B. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

C. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated.

D. MCCBs shall be equipped with a device for locking in the isolated position.

E. Lugs shall be suitable for 140 deg F (60 deg C) rated wire on 125-A circuit breakers and below 167 deg F (75 deg C) rated wire 194 deg F (90 deg C) rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70.

F. Standards: Comply with UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents.

G. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal 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.

H. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

I. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Long- and short-time pickup levels.
2. Long- and short-time time adjustments.
3. Ground-fault pickup level, time delay, and I-squared t response.

J. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

K. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
4. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
5. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.

2.7 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1) or gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12)

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
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 7 or Type 9 with cover attached by Type 316 stainless steel bolts.

3.2 INSTALLATION

A. 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 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 Construction Manager's written permission.
4. Comply with NFPA 70E.

B. 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.

C. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Install fuses in fusible devices.

G. Comply with NFPA 70 and NECA 1.

H. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "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. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of

insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

D. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify that the unit is clean.
e. Operate the circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.
h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate

values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.

e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.

g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.

h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.

i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION

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SECTION 26 29 13

ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.
3. Multispeed.

1.2 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.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 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 NFPA 70.

C. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Square D

B. Cutler-Hammer

C. Allen-Bradley

D. GE

E. Siemens

F. Or as approved by the Engineer.

2.2 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. Configuration: Nonreversing.
2. Surface mounting.
3. Pilot light.

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. Configuration: Nonreversing.

2. 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 bimetallic type.
3. Surface mounting.
4. Pilot light.

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. Configuration: Nonreversing.
2. 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 bimetallic type.
3. Surface mounting.
4. Pilot light.

E. Magnetic Controllers: Full voltage, across the line, electrically held.

1. Configuration: Nonreversing
2. Contactor Coils: Pressure-encapsulated type.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

3. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
4. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
5. Melting Alloy Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 20 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

6. Bimetallic Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 20 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

7. Solid-State Overload Relay:

    a. Switch or dial selectable for motor running overload protection.
    b. Sensors in each phase.

c. Class 20 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

8. External overload reset push button.

F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

1. Fusible Disconnecting Means:

a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
3. 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.

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.

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.

2.3 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. 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.

2.4 ACCESSORIES

A. Push Buttons, Pilot Lights, and Selector Switches: NEMA ICS 5; heavy-duty type; factory installed in controller enclosure cover unless otherwise indicated.

B. Control Relays: Auxiliary and adjustable time-delay relays.

C. 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height, and with disconnect operating handles not higher than 79 inches (2006 mm) 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 at walls, provide freestanding racks complying with Section 260529 "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 Section 033000 "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 Section 260548.16 "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 Section 262813 "Fuses."

G. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

H. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 260553 "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.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices.

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.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. 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 Owner 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. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches and overload-relay pickup and trip ranges.

B. 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 Owner before increasing settings.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION

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SECTION 26 29 23

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 SUMMARY

A. This section includes:

1. The work under this Section includes the furnishing of all labor, materials, equipment, and tools to perform the work indicated on the drawings or specified herein.

2. This Section includes solid-state, PWM, VFDs for speed control of three-phase, squirrel-cage induction motors.

1.02 REFERENCES

A. The specifications in this Section are subject to the administrative and procedural requirements specified in Division 1, as well as the broader requirements of the General Conditions

1.03 DEFINITIONS

A. BMS: Building management system.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFD: Variable frequency drive.

1.04 SUBMITTALS

A. All submittals shall be provided in accordance with requirements of Section 01 34 00.

B. Product Data: For each type of VFD. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

C. Shop Drawings: For each VFD.

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. Include the following:

a. Each installed unit's type and details.

b. Nameplate legends.

c. Short-circuit current rating of integrated unit.

d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.

e. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFDs. Provide schematic wiring diagram for each type of VFD.

D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFDs where pipe and ducts are prohibited. Show VFD 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.

E. Qualification Data: For manufacturer and testing agency.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For VFDs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 include the following:

1. Routine maintenance requirements for VFDs and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

H. 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.

I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

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 VFDs of a single type through one source from a single manufacturer. Each purchasing contractor either prime or sub, is responsible to coordinate with the other contractors to assure only one drive manufacturer is supplied for the entire project, no matter which subcontractor is purchasing it.

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 NFPA 70.

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, minimum clearances between VFDs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Shipping, handling and storage shall be in accordance with Section 01 60 00, Delivery, Storage and Handling.

B. Storage and Protection:

1. Deliver VFDs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

2. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

3. If stored in areas subject to weather, cover VFDs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

4. Upon delivery, all materials, equipment, and components shall immediately be stored and protected by CONTRACTOR in accordance with Section 01 60 00, Delivery, Storage, and Handling, and the manufacturer's instructions until installed in the Work.

5. Stored equipment shall be protected by CONTRACTOR against damage and exposure from the elements.

6. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.

7. Store all equipment in secure covered storage above the ground, separated by type, and prevent condensation and in accordance with the manufacturer's recommendations for long-term storage.

8. At no time shall the equipment be stored on earth or grass surfaces or come into contact with earth or grass. CONTRACTOR shall keep the equipment dry at all times

1.07 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: 0 to 40 deg C.

2. Humidity: Less than 90 percent (noncondensing).

3. Altitude: Not exceeding 3300 feet (1005 m).

B. 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. Indicate method of providing temporary electrical service.

3. Do not proceed with interruption of electrical service without **OWNER**'s written permission.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, including clearances between VFDs, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.08 COORDINATION

A. Coordinate layout and installation of VFDs 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 features of VFDs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

C. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

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

1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
2. Baldor Electric Company (Graham).
3. Eaton Corporation; Cutler-Hammer Products.
4. General Electric Company; GE Industrial Systems.
5. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
6. Siemens Energy and Automation; Industrial Products Division.
7. Square D.
8. Toshiba International Corporation.

2.02 EQUIPMENT

A. Variable Frequency Controllers

1. Description: NEMA ICS 2, IGBT, PWM, VFD; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
    a. Provide unit suitable for operation of standard-efficiency motor as defined by NEMA MG 1.
2. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
3. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.
4. Unit Operating Requirements:
    a. Input ac voltage tolerance of 240 V, plus or minus 5 percent.

b. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.

c. Minimum Efficiency: 96 percent at 60 Hz, full load.

d. Minimum Displacement Primary-Side Power Factor: 96 percent.

e. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

f. Starting Torque: 100 percent of rated torque or as indicated.

g. Speed Regulation: Plus or minus 1 percent.

5. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

   a. Electrical Signal: 4 to 20 mA at 24 V.

6. Internal Adjustability Capabilities:

   a. Minimum Speed: 5 to 25 percent of maximum rpm.

   b. Maximum Speed: 80 to 100 percent of maximum rpm.

   c. Acceleration: 2 to a minimum of 22 seconds.

   d. Deceleration: 2 to a minimum of 22 seconds.

   e. Current Limit: 50 to a minimum of 110 percent of maximum rating.

7. Self-Protection and Reliability Features:

   a. Input transient protection by means of surge suppressors.

   b. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

   c. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 30 performance.

   d. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.

   e. Instantaneous line-to-line and line-to-ground overcurrent trips.

   f. Loss-of-phase protection.

   g. Reverse-phase protection.

   h. Short-circuit protection.

   i. Motor overtemperature fault.

8. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

9. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

10. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

11. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

12. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

    a. Power on.

    b. Run.

    c. Overvoltage.

    d. Line fault.

    e. Overcurrent.

    f. External fault.

13. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

14. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

    a. Output frequency (Hz).

    b. Motor speed (rpm).

    c. Motor status (running, stop, fault).

    d. Motor current (amperes).

    e. Motor torque (percent).

    f. Fault or alarming status (code).

    g. PID feedback signal (percent).

    h. DC-link voltage (VDC).

    i. Set-point frequency (Hz).

    j. Motor output voltage (V).

15. Control Signal Interface:

    a. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.

    b. Pneumatic Input Signal Interface: 3 to 15 psig (20 to 104 kPa).

    c. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:

        1) 0 to 10-V dc.

        2) 0-20 or 4-20 mA.

3) Potentiometer using up/down digital inputs.

4) Fixed frequencies using digital inputs.

5) RS485.

6) Keypad display for local hand operation.

d. Output Signal Interface:

1) A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

a) Output frequency (Hz).

b) Output current (load).

c) DC-link voltage (VDC).

d) Motor torque (percent).

e) Motor speed (rpm).

f) Set-point frequency (Hz).

e. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

1) Motor running.

2) Set-point speed reached.

3) Fault and warning indication (overtemperature or overcurrent).

4) PID high- or low-speed limits reached.

16. Communications: Provide an RS485 interface allowing VFD to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFD to be programmed via BMS control. Provide capability for VFD to retain these settings within the nonvolatile memory. Provide BACnet and Modbus communication protocols allowing interface with the process and HVAC control systems. All outputs shall be able to be communicated via either communications protocol.

17. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).

18. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

B. ENCLOSURES

1. CONTRACTOR shall provide NEMA 12 enclosures for all variable frequency drives located indoors.

2. CONTRACTOR shall provide NEMA 3R enclosures for all variable frequency drives located outside.

C. ACCESSORIES

1. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

2. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

3. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

4. Control Relays: Auxiliary and adjustable time-delay relays.

5. Standard Displays:

a. Output frequency (Hz).

b. Set-point frequency (Hz).

c. Motor current (amperes).

d. DC-link voltage (VDC).

e. Motor torque (percent).

f. Motor speed (rpm).

g. Motor output voltage (V).

h. Power Input (kW) (Capable of being communicated via the Modbus or BACnet interface).

6. Historical Logging Information and Displays:

a. Real-time clock with current time and date.

b. Running log of total power versus time.

c. Total run time.

d. Fault log, maintaining last four faults with time and date stamp for each.

D. FACTORY FINISHES

1. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFDs before shipping.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

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

3.02 IDENTIFICATION

A. Identify VFDs, components, and control wiring according to Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.

3.03 CONNECTIONS

A. Conduit installation requirements are specified in other Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Section "Grounding and Bonding for Electrical Systems."

3.04 INSTALLATION

A. Anchor each VFD assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Coordinate mounting and anchoring of VFDs with drawing details. If drawing details are explicit, delete paragraph below. Retain for floor-mounting equipment.

C. Comply with mounting and anchoring requirements specified in Section "Hangers and Supports for Electrical Systems."

3.05 APPLICATION

A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.

3.06 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect controllers, wiring, components, connections, and equipment installation.

2. Report results in writing.

C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

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

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. 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.

3.07 ADJUSTING

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

3.08 DEMONSTRATION

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

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SECTION 26 32 13

ENGINE GENERATOR
(BID ALTERNATE)

PART 1 - GENERAL

1.01 SUMMARY

A. Description of System

1. Provide diesel engine driven electric generating unit, factory assembled, with minimum continuous output rating as indicated on the DRAWINGS, for 208/120 volt, 3 phase, 4 wire, 60 hertz, grounded neutral service, fully rated for operation at 1000 feet above sea level in an ambient temperature range of 95 degF maximum to 40 degF minimum. System shall consist of a diesel engine, direct-connected generator, exciter, exhaust system, automatic starting equipment, instrument panel, control panel, instruments and controls, all mounted on a common steel base suitable for outdoor installation on steel spring isolators. Provide complete with an automatic transfer switch, battery, charger, and all accessories as specified and required for normal operation in standby service.

1.02 QUALITY ASSURANCE

A. Reference Specifications and Standards

1. Furnish equipment meeting all applicable requirements of SAE, IEEE, NEMA, NEC and ANSI/NFPA 110 Standards.

B. Qualifications of Manufacturers

1. The engine, generator and all major items of auxiliary equipment shall be by U.S. Manufacturers currently producing such equipment. The manufacturer shall assemble and test the unit at the factory and ship to the project site through his authorized dealer. Dealer shall have a parts and service facility within 50 miles of the site.

C. Source Quality Control

1. Perform all normal factory tests including maximum and continuous net brake horsepower over the operating speed range, with the proposed engine fully equipped with required accessories.

1.03 SUBMITTALS

A. Submit manufacturer’s complete drawings of the proposed engine-generator set, with dimensions, weight and foundation requirements, including drawings and literature covering auxiliary equipment. Delineate unit by make of engine, number of cylinders,

compression ratio, bore and stroke, piston displacement and speed, make and type of governor, make and type of generator, electrical rating and operating curves, number and type of bearings, and exciter type. Certify the generator output to be equal to or greater than the requirements of the CONTRACT DOCUMENTS.

1. Muffler with sound attenuation data for the eight octave bands.
2. Type and number of batteries, and battery rack.
3. Battery charger.
4. Engine instrument/control panel(s).
5. Instrument/Control Panel(s).
6. Radiator.
7. Outdoor weatherproof enclosure. Access panels to be fitted with lockable hardware.
8. Fuel Tank
9. All electrical control and piping diagrams.
10. Vibration isolation system data and calculations.
11. Sound pressure levels measured in accordance with ARI-575, “Standard for Method of Measuring Machinery Sound within Equipment Rooms”.

B. Submit certified test reports of previous tests on identical equipment under actual conditions, not simulated, where test data is available.

C. Guarantee that the diesel engine driven electric generating unit, and its auxiliaries, shall meet the operating conditions, capacity and performance specified, and shall remain in serviceable working condition, for a period of one year from date of final completion and acceptance of the system by the OWNER; and that if the unit, or its auxiliaries, fail or fail to meet any of the specified requirements, the unit or its affected auxiliaries, shall promptly be reworked or replaced, as necessary to comply with the CONTRACT requirements, all at no cost to the OWNER, and the guarantee shall be extended for one year from date of acceptance of the reworked or replaced unit or auxiliary.

D. Buy America Act Certification: Submit documentation certifying that products comply with provisions of the Buy America Act.

1.04 MAINTENANCE DATA AND OPERATING INSTRUCTIONS

A. Furnish operating and maintenance instruction manuals covering complete operating, service, and repair instructions for the equipment furnished, and complete illustrated parts breakdown with manufacturer’s name, nomenclature and part number for each component part and assembly. Include location of nearest source of supply and service.

1.05 SPECIAL TOOLS

A. Furnish to the OWNER a complete set of all special tools required to operate and service the equipment as recommended by the manufacturer for field maintenance.

1.06 SPARE PARTS

A. Provide the following listed spare parts:

1. One oil filter replaceable element.
2. One air filter replaceable element.
3. One fuel oil filter replaceable element.

1.07 ENGINEERING FIELD SERVICE

A. Require the manufacturer of the generator set to provide a qualified erection engineer to check the complete equipment after all equipment is installed and wired including setting, alignment, field connections, testing and start-up. Furnish to the OWNER the manufacturer's written certification assuring that each item of equipment is complete, in good condition, free from damage, and properly installed, connected and adjusted. Require the manufacturer's engineer to make any electrical or mechanical adjustments or replacements which may be necessary to insure the proper functioning of the equipment furnished and to instruct the OWNER'S personnel in operation and maintenance of the equipment.

1.08 STANDARDS

B. Buy America – U.S. Department of Transportation Requirements: The contractor agrees to comply with 49 U.S.C. § 5323(j), as amended by MAP-21 and 49 C.F.R. part 661, to the extent consistent with MAP-21, and subsequent amendments to those regulations that may be promulgated. The Contractor also agrees to comply with FTA directives to the extent those directives are consistent with MAP-21, except to the extent that FTA determines otherwise in writing. Buy America requirements state that Federal funds may not be obligated unless steel, iron, and manufactured products used in FTA-funded projects are produced in the United States, unless a waiver has been granted by FTA or the product is subject to a general waiver. General waiver requirements are listed in 49 CFR 661.7.

C. NFPA Compliance:

1) Comply with NFPA 37.
2) Comply with NFPA 70.
3) Comply with NFPA 99.
4) Comply with NFPA 110 requirements for Level **1** EPSS

D. Engine Exhaust Emissions: Comply with EPA Tier **3** requirements and applicable state and local government requirements.

PART 2 - PRODUCTS

2.01 FABRICATION AND MANUFACTURE

A. Manufacturer

1. Engine Generator Set and Components:

a. Cummins
b. Caterpillar
c. Kohler
d. Generac

B. Engine Requirements

1. General Engine Description. Naturally aspirated or turbo-charged, aftercooled, industrial, multi-cylinder, four stroke cycle, in-line or "V", liquid cooled, diesel type with spark ignition and rated speed of 1800 RPM at full load for operation on No. 2 domestic burner fuel. Minimum rating of 1.47 HP/KW.
2. Fuel System. Complete with engine-mounted fuel filter, fuel pressure gauge and fuel priming pump, all subject to approval by the OWNER'S Underwriters.
3. Lubrication System. Full pressure type with engine-driven positive displacement sump pump, full flow strainer, full flow filter, pressure relief and bypass valves, crankcase ventilator with filter, bayonet type oil level indicating pressure gauges on the upstream and downstream side of the strainer and filter, drain connection, oil cooler, and low oil pressure safety shutoff device. Provide coolant shutoff valves and drain on the oil cooler to facilitate draining coolant without draining the complete engine cooling system. Provide lubricant.
4. Cooling System. Pressure type, with radiator, pusher-type fan, engine driven circulating pump, radiator cap incorporating a pressure vacuum valve, thermostat in conjunction with a radiator bypass, drain connection, and a high coolant temperature safety device. Provide gaskets and packing in the cooling system which are unaffected by ethylene-glycol base coolant. Provide coolant for minus 35 degC.
5. Air Intake System. Complete with dry type filter and high frequency filter-type silencer for reducing the sound level at the intake to a point acceptable for residential use.
6. Exhaust System. Furnish a convoluted, seamless tube flexible exhaust section, 125 pound type of proper size and configuration to match the flanged exhaust outlet of the engine. Furnish a silencer of the residential type capable of reducing ambient exhaust noise level to 60 dBA, when measured 50 feet from the engine under full engine load and clear weather.
7. Immersion Heater System. Provide immersion heaters to maintain engine coolant and lube oil temperature in readiness for fast starting. Provide heater in fuel daytank if unit is mounted outdoors.

C. Electric Starting System

1. General Starting Description. Not less than 24 volt, consisting of a heavy duty electric cranking motor with drive mechanism, heavy duty storage batteries with

metal frame or box, battery charger, associated switches, relays, connectors, meters, wiring and protective devices.

2. Cranking Motor. Capable of cranking the engine five times in rapid succession without overheating the motor and at sufficient speed for starting in ambient temperatures as low as minus 30 degC.
3. Storage Batteries. Sealed lead-acid or equivalent nickel-cadmium type of voltage and capacity as determined by the engine manufacturer with sufficient capacity to start the generator set five times consecutively as specified.
4. Battery Charger. Automatic, self-protected, temperature compensated, self-regulated, voltage reference float type providing continuous taper charging, current-limiting type of a capacity determined by the engine manufacturer and sufficient to automatically recharge the batteries quickly according to the requirements governed by battery discharge duty, and suitable for 120 volt, single phase, 60 hertz input service from a remote receptacle panel. It shall include overcurrent protection, silicon diode full wave rectifiers, voltage surge suppressors, D.C. ammeter, D.C. voltmeter, on-off switch and pilot light. It shall have lights for “AC Failure”, “Rectifier Failure”, “High DC Voltage”, “Low DC Voltage” and “Load Disconnect”, and provide a contact for remote alarm, for each condition. The contacts shall be wired in parallel to provide for a remote summary alarm indication. It shall have crank disconnect provisions. Chargers with timers are not acceptable.

D. Governor

1. Governor. Hydraulic, adjustable isochronous, suitable for providing accurate speed control and speed droop stabilization. Response Characteristics:
    a. Maximum Observed Speed Band. Plus or minus 0.25% deviation from rated at constant load.
    b. Speed Droop. Adjustable from 0% to 7% for load application from no-load to full load.

E. Safety Devices

1. Safety Controls, Switches and Circuitry. Equip the engine with the following safety controls, switches, and circuitry which will shut down the engine and open the generator main circuit breaker.
    a. Overspeed Stop. Operate between 115% and 125% of rated speed.
    b. High Coolant Temperature Cutout. Adjustable, with protection against accidental movement of adjustment, and set to operate when coolant temperature exceeds engine manufacturer’s recommended operating temperature.
    c. Low Oil Pressure Cutout. Adjustable type, with protection against accidental movement of adjustment, and set to operate when oil pressure drops below the minimum recommended by the engine manufacturer.
    d. Engine Overcrank Cutout. Adjustable timer (15 to 60 seconds) control in the automatic start panel, to shut down the engine cranking motor after a preset time.

e. Emergency Stop Switch. Break glass switch in NEMA 3 enclosure. Locate at exterior main enclosure door on strike side. Provide with nameplate reading “Diesel Generator Emergency Shutdown and Fuel Flow Stop”. Arrange so that activation of break glass switch shuts down fuel supply to the Diesel engine.

F. Generator

1. Generator. Alternating current, single bearing, direct connected, separately excited, externally regulated, synchronous type, Class F insulated for 105 degC rise above 40 degC ambient, with an amortisseur winding, in a drip-proof, self-ventilated enclosure, with a continuous rating as specified, and conforming to the referenced standards including waveform, and telephone influence factors. Bring out all leads from each winding to a generator main lead terminal box adequate in size for making up all connections and grounding the neutral to the generator frame. Provide a suitable neutral grounding connection at the generator accessible for grounding the neutral to the generator set supporting frame. Bring out all low voltage leads in a terminal box separate from the generator main leads. Provide a suitable generator field discharge resistor, automatically connected and disconnected as required.
2. Generator Output Circuit Breaker. Provide an output circuit breaker with shunt trip, in a separate NEMA 12 enclosure mounted and wired on the unit assembly. Circuit breaker shall be 100% rated and shall be provided with four convertible or form “C” auxiliary contacts to monitor position. Circuit breaker shall be insulated case, heavy duty, with true RMS digital sensing trip unit, similar to General Electric “Power Break” design.

G. Exciter

1. Built-in brushless alternator type exciter mounted on the generator shaft, directly connected to the generator field windings without intervening brushes, slip rings or commutators, and consisting of not less than six solid-state, hermetically sealed rectifiers and surge protection device.

H. Voltage Regulation

1. Static type, three phase voltage regulator, mounted either on the generator control panel or combined with the exciter. Provide a device for manual adjustment of the regulated voltage over a range of 10% above and below rated voltage under all operating conditions of the generator, while the unit is operating. Provide a “manual-automatic” switch to permit selection of manual control of voltage by exciter rheostat or automatic control by the regulator.

I. Manual and Automatic Start-Unattended Operation

1. General Description. Provide the complete automatic engine starting control and automatic load transfer switch. Design the automatic equipment to start the emergency generator and transfer load to the emergency source after a drop in voltage below an adjustable predetermined value occurs in any one or more phases of the 3 phase normal electrical service, and then automatically restore the

load to the normal source, stop the generator set and reset itself for another complete cycle of operation within an adjustable predetermined time period after return of the normal service voltage to an adjustable predetermined value of the normal voltage in all phases.

2. Automatic Engine Starting Control. Initiate the automatic engine starting control by an auxiliary contact on the automatic load transfer switch to concurrently and automatically open the wall closure cooling air exhaust damper (normally closed contact), and energize the engine cranking motor and fuel solenoid valve or throttle control, so that fuel may be instantaneously delivered to the cylinders independent of the safety shutdown equipment. As soon as the engine begins to operate under its own power, regardless of its speed or the AC generator voltage, de-energize the cranking motor. Should the generator set fail to start or establish 90% of rated AC voltage and frequency within 75 seconds after a normal power failure, discontinue the starting cycle, stop the engine (if it has started), and annunciate the particular sequential "failure to operate" on the generator control panel. If 90% AC voltage is generated within the 75 second period, establish normal functioning of all engine safety devices and reset the automatic starting control for another failure of normal power. When the engine stops due to functioning of the low oil pressure, high coolant temperature, overcrank, or over-speed safety devices, maintain the automatic starting control in the "tripped-out" position and annunciate that the particular failure has occurred on the generator control panel. Provide a three position "Manual-Off-Auto" selector switch on the generator control panel for the following operations:

   a. Resetting of the automatic engine control after a failure has occurred by moving the selector switch from "Auto" to "Off" and back to "Auto"
   b. Manually starting and operating the engine without transferring load by placing the selector switch in the "Manual" position.
   c. Preventing operation of the generator set manually or automatically by placing the selector switch in the "Off" position.

3. Automatic Load Transfer Switch. 3 pole, open-transition with overlapping neutral contacts, double throw type, electrically-operated, mechanically-held, ampere rated as indicated on the DRAWINGS at 600 volts AC for any type of load, inductive, tungsten or combined, conforming to the requirements of UL 1008, and housed in a NEMA 3R enclosure for wall or floor mounting. Provide switch with solderless terminal lugs for external cable connections. The "withstand rating", when protected by (a molded case circuit breaker, shall not be less than 65,000 amperes at 480 volt AC (current limiting fuses, shall not be less than 100,000 amperes). Equip switch with a transfer coil operated by momentary energization from the source which the load is to be served after transfer takes place, and with heavy duty, replaceable, adjustable main contacts which positively lock on either source of power. Equip main contacts with separate arcing contacts, and do not provide a "neutral" or "Off" position of the main contacts. Design the control circuitry to pilot the engine starting control, to transfer load to the engine-generator set when the normal supply voltage in any phase drops below a predetermined value, adjustable from 85 to 100% normal, to retransfer the load to the normal source when the normal supply voltage is restored to a predetermined value, adjustable from 85 to 100% normal for a

predetermined time adjustable from 0 to 30 minutes, and to automatically stop the generator set after an adjustable 0 to 5 minute time delay for a no-load run. Provide the following features and equipment in addition to those specified.

a. Delay time in initiation of the engine starting control, adjustable from 0 to 2 minutes.
b. Indication that the load is on the emergency source by an indicating light.
c. Prevent transfer of the load to the emergency source until voltage and frequency have reached at least 90% of the rated values by a voltage and frequency sensitive relay.
d. Permit simulation of normal power failure without load transfer, by a maintained contact test switch.
e. Permit manual retransfer of the load to the normal power source during the adjustable 5 to 30 minute delayed return transfer period by a momentary contact switch.
f. Permit the load to be served from the emergency source on a continuous basis, regardless of the suitability of the normal power source, by a maintained contact switch.
g. Provide a remote annunciator for the generator and transfer switch; location to be as shown on the drawings. Automatic transfer switches shall be fully enclosed equipment designed for indoor installation as noted on building plans. Transfer switch and generator shall be furnished by the same supplier.

h. PERFORMANCE REQUIREMENTS

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 ICS 1
3) Retain one of first two paragraphs below, or both, if applicable to Project
4) Comply with NFPA 99.
5) Comply with NFPA 110.
6) Comply with UL 1008 unless requirements of these Specifications are stricter.
7) Coordinate "Indicated Current Ratings" Paragraph below with Drawings and indicate percentage of tungsten filament lamp load for switches where it exceeds 30 percent. This percentage may affect switch selection. Some manufacturers' ratings for some switch lines apply to all classes of load, including tungsten lamps.
8) 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.

J. Instrument/Control Panel(S)

1. Instrumentation/Control Panel(s). Provide one or more panels mounted on the common steel supporting base, or on the engine or generator, containing the

following items fully identified by means of permanent type approved nameplates. Provide vibration isolation between panel(s) and supports.

a. Oil pressure gauge.
b. Coolant temperature gauge.
c. Fuel pressure gauge.
d. Engine starting control Manual-Off-Auto selector switch. Provide a 20 Dry Contact Kit normally open, and normally closed gold plated contacts in a form C configuration to activate warning devices and other customer provided accessories allowing monitoring of the generator set by the Facility Management and Control System (FMCS), or as desired.
e. Engine "Start" and "Stop" push buttons.
f. Running time totalizing meter.
g. Audible and visible alarm annunciation of the following:

1) Failure to crank.
2) Failure to generate.
3) Overspeed stop.
4) High coolant temperature.
5) Lube low oil pressure.
6) Overcrank.
7) Engine low coolant level.
8) Engine high coolant temperature pre-alarm.
9) Lube low oil pressure pre-alarm.

h. Main circuit breaker, molded case type, with shunt trip, over-current and short circuit current trip.
i. DC voltmeter and ammeter.
j. Voltage regulator and/or voltage adjusting rheostat.
k. Frequency meter, indicating 55-65 hertz.
l. Three current transformers and 2 potential transformers for metering.
m. AC voltmeter, single phase, and transfer switch.
n. AC ammeter, single phase, and transfer switch.
o. Kilowatt hour meter.
p. Watt transducer, Scientific Columbus "Exceltronic", (4-20 mA or 0-1 mV) output wired to an accessible terminal strip.

K. Switchboard Wiring

1. All control wiring within the generator termination cubicles, master control panel, and the generator control panel(s) shall be single conductor, Type SIS, flexible stranded copper, tinned wire, with insulation for 600 volts working and 4000 volts test, rated 90 degC for switchboard wiring.
2. Provide connections between hinged and stationary panels with terminal blocks and extra flexible wire having the same insulation as the panel wiring and secure wire between terminal blocks with wire cleats to prevent movement at the terminal blocks.
3. Connect all current transformer secondary leads to accessible short circuiting terminal blocks with provisions for retention of the shorting devices.

4. Provide plug-in terminal blocks for all conductors to be continued across all shipping splits.
5. Provide wire markers at each end of all control wiring conductors.
6. Provide an additional circuit breaker to be used strictly for load testing with a portable load bank.

L. Packaged Fuel Oil Tank

1. Provide manufactures standard above ground diesel fuel storage tank; sized for 24 hour continuous run with all required accessories.

M. Outdoor Weatherproof Enclosure

1. Provide as an integral part of the generator assembly. Fabricate enclosure of a rigid frame with walls of painted, fire-and-weather-resistant materials. The walls shall be made up of removable panels, except that where frequent access is required to electrical panels and for inspection, adjustments and filter replacements, provide hinged panels with three-point lock set hardware. Provide screened louvers for ventilation. The entire enclosure shall be rodent-and-bird-proof, and shall be rain-and-dust-tight. Roof shall provide a drip shield to protect walls and hinged panels and to keep water from entering the enclosure or ice from freezing the enclosure closed. Provide mounting brackets, supports, piping, etc., on the roof for the exhaust muffler. Locate the position of the muffler in regard to prevailing winds and adjacent buildings so that the exhaust does not present a problem.
2. The enclosure shall suppress the noise from the engine generator set running at full load to a maximum sound level of 86 dBA measured at 7 meters.
3. Hinged panel shall be equipped with lockable hardware.

N. General Features

1. Vibration Control. Mount the engine and generator on a rigid structural steel base common to both components, with spring isolators selected to provide 95% isolation to minimize vibration of the remainder of the skid-mounted equipment and transmission of vibration to the supporting pad. The steel springs shall be neoprene coated and all other steel components shall be hot-dip galvanized.
2. Protection of Operating Personnel. Insulate, fully enclose or suitably guard all exposed parts which operate at extremely high temperatures, or which are energized electrically, and all rotating or reciprocating parts. Ground all noncurrent carrying parts of electrical equipment to the steel base and provide a suitable terminal stud or grounding pad attached to the steel base. Ground the generator neutral to the supporting steel base when 4-pole switch is used.
3. Corrosion Protection. Treat all exposed equipment to resist corrosion. Provide bolts, screws, nuts, washers, and other small parts of suitable corrosion-resisting material or treat to resist corrosion.
4. Factory Painting. Thoroughly clean all equipment, and prime and finish paint with manufacturer’s standard paint finish.
5. All unit mounted equipment and electrical components shall be mounted in fully sealed enclosures to prevent unauthorized entry from top, sides or bottom.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the emergency generation system equipment at locations indicated. Securely anchor the generator set and the supporting steel base to the vibration isolators, and the vibration isolators to the concrete foundation. Adjust the isolators for proper operation per manufacturer's instructions. Mount the automatic transfer switch at the wall with 1/4 inch separation from same and secure to supports.

B. Provide all power and control connections.

C. Ground the generator frame and supporting steel base to the ground mat below the unit with 4/0 cables. Make bolted connections.

D. All external connections to the engine and the generator shall be flexible type for a minimum distance of three feet from the engine and the generator.

E. Ground the generator neutral to the grounded supporting steel base of the engine generator.

3.2 FUNCTIONAL PERFORMANCE AND LOAD TESTING

A. Contractor shall arrange to have functional performance and load testing performed by an authorized engine generator manufacturer's technician. Testing shall be conducted in accordance with manufacturer's instructions. Tests shall be witnessed by the Architect/Engineer.

B. Generator to be load tested using a portable load bank. The duration of the test shall be 6 hours with generator operating at full load capacity for 2 hours and at 50% load for 4 hours. Contractor shall supply fuel required to conduct load bank tests. Upon completion of final test, contractor shall refill generator fuel tank to 80% capacity level.

C. Contractor shall be responsible for submission of all documentation associated with engine generator performance and load testing.

3.3 TRAINING

A. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. Provide competent, factory authorized personnel to provide instruction to Owner's operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed engine generator systems. The instruction shall be scheduled by the contractor in coordination with the Owner's Representative after submission and approval of formal training plans.

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SECTION 26 36 00

TRANSFER SWITCHES
(BID ALTERNATE)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes automatic transfer switches rated 600 V and less, including the following:

1. Bypass/isolation switches.
2. Remote annunciator system.
3. Remote annunciator and control system.

1.03 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 transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. 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.
4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative.

B. Seismic Qualification Data: Certificates, for transfer switches, 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.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Features and operating sequences, both automatic and manual.
b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications:

1. Member company of NETA.

a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.07 FIELD 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 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 Construction Manager's written permission.

1.08 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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

B. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

F. 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.

G. Tested Fault-Current Closing and Short-Circuit 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.
2. Short-time withstand capability for three cycles.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall

be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Service-Rated Transfer Switch:

1. Comply with UL 869A and UL 489.
2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
3. In systems with a neutral, the bonding connection shall be on the neutral bus.
4. Provide removable link for temporary separation of the service and load grounded conductors.
5. Surge Protective Device: Service rated.
6. Ground-Fault Protection: Comply with UL 1008 for normal bus.
7. Service Disconnecting Means: External disconnect per drawings.

L. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

M. Neutral Terminal: Solid and fully rated unless otherwise indicated.

N. 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.

O. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

P. 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.

Q. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "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.
4. Accessible via front access.

R. Enclosures: General-purpose NEMA 250, Type 3R, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.02 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

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

1. Cummins Power Generation.
2. Eaton.
3. GE Zenith Controls.
4. Generac Power Systems, Inc.
5. Kohler Power Systems.
6. MTU Onsite Energy Corporation.

B. Comply with Level 1 equipment according to NFPA 110.

C. 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 unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: Compression type.
7. Ground Lugs and Bus-Configured Terminators: Compression type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

E. 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.

F. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

G. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

H. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from

1 to 30 seconds.

I. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

J. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate 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 shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
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 zero to 30 minutes, and factory set for 10 minutes. Override shall 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 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 shall be adjustable from 10 to 30 minutes. Factory settings shall be 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 unavailable.

2.03 TRANSFER SWITCH ACESSORIES

A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
d. Transition: Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
e. Transition: Provide open-transition operation when transferring between power sources.
f. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
g. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
h. Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.
i. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
j. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
k. Maintainability: Fabricate to allow convenient removal of major

components from front without removing other parts or main power conductors.

4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

B. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
3. Annunciation panel display shall include the following indicators:

    a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
    b. Switch position.
    c. Switch in test mode.
    d. Failure of communication link.

4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

    a. Indicating Lights: Grouped for each transfer switch monitored.
    b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
    c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
    d. Lamp Test: Push-to-test or lamp-test switch on front panel.

C. Remote Annunciator and Control System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Include the following functions for indicated transfer switches:

    a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
    b. Indication of switch position.
    c. Indication of switch in test mode.
    d. Indication of failure of digital communication link.
    e. Key-switch or user-code access to control functions of panel.
    f. Control of switch-test initiation.
    g. Control of switch operation in either direction.
    h. Control of time-delay bypass for transfer to normal source.

3. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically shall revert to standalone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

4. Remote Annunciation and Control Panel: Solid-state components. Include the following features:

    a. Controls and indicating lights grouped together for each transfer switch.
    b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
    c. Digital Communication Capability: Matched to that of transfer switches supervised.
    d. Mounting: Flush, modular, steel cabinet unless otherwise indicated.

2.04 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. 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.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency systems. Include results of test for the following conditions:

    a. Overvoltage.
    b. Undervoltage.
    c. Loss of supply voltage.
    d. Reduction of supply voltage.
    e. Alternative supply voltage or frequency is at minimum acceptable values.
    f. Temperature rise.
    g. Dielectric voltage-withstand; before and after short-circuit test.
    h. Overload.
    i. Contact opening.
    j. Endurance.
    k. Short circuit.
    l. Short-time current capability.
    m. Receptacle withstand capability.
    n. Insulating base and supports damage.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete.

2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
4. Provide workspace and clearances required by NFPA 70.

B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

C. Identify components according to Section 260553 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Comply with NECA 1.

3.02 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, 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. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."

G. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."

H. Route and brace conductors according to manufacturer's written instructions. Do not obscure manufacturer's markings and labels.

I. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

J. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

3.03 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 test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding, and required clearances.
    d. Verify that the unit is clean.
    e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
    f. Verify that manual transfer warnings are attached and visible.
    g. Verify tightness of all control connections.
    h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

        1) Use of low-resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

    i. Perform manual transfer operation.
    j. Verify positive mechanical interlocking between normal and alternate sources.
    k. Perform visual and mechanical inspection of surge arresters.
    l. Inspect control power transformers.

        1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
        2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
        3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:

a. Perform insulation-resistance tests on all control wiring with respect to ground.
b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
c. Verify settings and operation of control devices.
d. Calibrate and set all relays and timers.
e. Verify phase rotation, phasing, and synchronized operation.
f. Perform automatic transfer tests.
g. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Engine start sequence.
3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

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, perform each electrical test for transfer switches stated in NETA ATS and 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 retransfer from 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 one 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. Coordinate tests with tests of generator and run them concurrently.

E. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

F. Transfer switches will be considered defective if they do not pass tests and inspections.

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

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.04 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION

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SECTION 26 51 00

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.
2. Exit signs.
3. Lighting fixture supports.

B. Related Sections:

1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 26 27 26 "Wiring Devices".

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. Lumen: Measured output of lamp and luminaire, or both.

D. Luminaire: Complete lighting fixture, including driver housing if provided.

1.4 ACTION 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. Ballast, including BF.
3. Energy-efficiency data.

4. Life, output (lumens, CCT, and CRI).
5. 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. Installation instructions.

1.5 INFORMATIONAL SUBMITTALS

A. 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 (305 mm) 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.

B. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

C. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. 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.

1.7 MATERIALS MAINTENANCE SUBMITTALS

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

1. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 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, complying with the IESNA Lighting Measurements Testing & Calculation Guides.

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.

E. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

1.9 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.

1.10 WARRANTY

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products 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. Metal Parts: Free of burrs and sharp corners and edges.

C. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

D. 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.

2.3 DRIVERS FOR LED LAMPS

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. Recessed Fixtures: Comply with NEMA LE 4.

C. Bulb shape complying with ANSI C79.1.

D. Lamp base complying with ANSI C81.61.

E. CRI of minimum 80. CCT of 4100 K.

F. Rated lamp life of 50,000 hours.

G. Lamps dimmable from 100 percent to 0 percent of maximum light output.

H. Internal driver.

I. Nominal Operating Voltage: As indicated on plans. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

2.4 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

2.5 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).

F. Rod Hangers: 3/16-inch (5-mm) 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.

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. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
2. 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 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

D. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), 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 point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

E. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. 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.

3.3 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 100 hours at full voltage.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two 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.

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SECTION 26 56 19

LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.

2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale and coordinated.

B. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

C. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.6 FIELD CONDITIONS

A. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61.

F. CRI of minimum 80 CCT of 4100 K or as indicated.

G. L70 lamp life of 50,000 hours.

H. Lamps dimmable from 100 percent to 0 percent of maximum light output.

I. Nominal Operating Voltage: 120 V ac or 277 V ac.

J. In-line Fusing: Separate in-line fuse for each luminaire.

K. Lamp Rating: Lamp marked for outdoor use.

L. Source Limitations: Obtain luminaires from single source from a single manufacturer.

M. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 LUMINAIRE TYPES

A. AS indicated on drawings.

2.3 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: As specified on luminaire schedules. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

2.4 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. 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 requirements; 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 indicated on luminaire schedules.

D. 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, 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 or SSPC-SP 8.
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 color.
c. Color: As selected by Architect from manufacturer's full range.

2.5 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260559 "Hangers" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to a minimum 1/8 inch (3 mm) backing plate attached to wall structural members or through bolts and backing plates on either side of wall.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.

I. Coordinate layout and installation of luminaires with other construction.

J. 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.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections and wiring methods.

3.2 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections.

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. 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 IES testing guide(s):

a. IES LM-5.
b. IES LM-50.

c. IES LM-52.
d. IES LM-64.
e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

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

E. 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.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION

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SECTION 28 31 00

FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.01 SCOPE

A. Scope includes a completely new fire alarm system for the facility.

B. Work is to be phased to allow temporary occupancy of building final certificate of occupancy.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Surge Voltages in Low-Voltage AC Power Circuits.

2. National Fire Protection Association (NFPA):

a. 70, National Electrical Code (NEC).
b. 72, National Fire Alarm Code.
c. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
d. 101, Code for Safety to Life from Fire in Buildings and Structures.

3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).

4. National Institute for Certification in Engineering Technologies (NICET).

5. Underwriters Laboratories, Inc. (UL):

a. 286A, Smoke Detectors for Duct Application.
b. 464, Audible Signal Appliances.
c. 497B, Protectors for Data Communication and Fire Alarm Circuits.
d. 864, Control Units for Fire-Protective Signaling Systems.
e. 1449, Standard for Transient Voltage Surge Suppressors.
f. 1638, Visual Signaling Appliances – Private Mode Emergency and General Utility Signaling.

1.03 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. CAD: Computer Aided Design.

C. Coded: Audible or visible signal that conveys information about alarm event. Examples are, number of rings of a bell or flashes of a strobe. This could be used to convey location or type of alarm.

D. dB: Decibels.

E. DXF: Drawing Interchange Format.

F. FACP: Fire Alarm Control Panel.

G. HVAC: Heating, Ventilating, and Air Conditioning.

H. I/O: Input/Output.

I. LCD: Liquid Crystal Display.

J. LED: Light-Emitting Diode.

K. Zone: A defined area within the protected premises. A zone can define an area from which an alarm signal can be received or an area to which a signal can be sent. The term zone is typically used when describing conventional, nonaddressable systems.

1.04 SYSTEM DESCRIPTION

A. Design Requirements:

1. Provide new addressable fire-alarm system for building.
2. Contract Drawings show location of fire alarm panel(s), duct detectors, smoke detectors, manual pull stations, and horn/strobe devices.
3. Installation shall meet requirements of the 2018 North Carolina Fire Prevention Code, NFPA.
4. Conduit layout and wiring interconnection of devices as specified herein, and for interconnection of flow and supervisory switches.
5. Coordinate, and include in design, requirements for interfacing with HVAC system.

B. Performance Requirements:

1. Actuation of alarm (smoke detector, flow switch, or other normally open initiating device contact) or trouble (trouble or supervisory switch) shall cause the following operations:
    a. Audible and visual indications of alarmed devices on fire alarm control panel display.
    b. Fire alarm control panel shall transmit common alarm or trouble signal to fire alarm dialer.
2. Fire alarm control panel shall de-energize HVAC equipment equipped with return or supply air duct mounted detectors
3. Actuation of duct smoke detectors shall signal a dry contact closure to the associated piece of HVAC equipment to de-energize the unit. Contact output shall be rated 10A at 120V.

4. Fire alarm systems shall be fully serviceable and programmable by Owner and shall be U.L. certified as installed.

1.05 SUBMITTALS

A. The contractor shall submit shop drawings of the fire alarm system to Owner for review. The plan drawing showing devices, system riser, system interconnection drawings, and manufacturer's specification sheets shall be included. Drawings shall include design ambient sound level, audible alarm device sound power and alarm sound level for each space. Additional devices required while verifying the system shall be at contractor's expense.

B. Action Submittals:

1. Descriptive product information for each individual system component.
2. Dimensional drawings of panels and associated equipment.
3. Operating instructions.
4. Control panel configuration and module data.
5. Alarm initiating, indicating, and supervisory device electrical data.
6. The contractor shall submit shop drawings of the fire alarm system for review. The plan drawing showing devices, system riser, system interconnection drawings, and manufacturer's specification sheets shall be included. Drawings shall include design ambient sound level, audible alarm device sound power and alarm sound level for each space. Additional devices required while verifying the system shall be at contractor's expense. Plans showing device and panel locations as well as conduit and cable sizes. Prepare drawings and diagrams on drawing sheets of uniform size without extraneous information. Marked up electrical or similar drawings or copies of catalog data sheets are not acceptable in lieu of required drawings or diagrams.
7. Sequence of Operation Matrix.
8. Supervisory power requirements for equipment.
9. Alarm power requirements for equipment.
10. Power supply rating justification showing power requirements for system power supplies.
11. Voltage drop calculations for wiring runs, demonstrating worst case condition.

B. Informational Submittals:

1. Experience and qualifications of firm(s) proposed to design and install system.
2. Certifications documenting service technician's training. Certification shall indicate name of individual, training, dates, systems qualified, and status.
3. Copy of design documents, Shop Drawings, and calculations submitted to code-enforcement authorities.

4. Factory test reports.

5. Operation and Maintenance Data as specified in Division 1.

6. Detailed program and schedule for testing, inspection, and maintenance of fire alarm system that satisfies requirements of NFPA 72, manufacturer's recommendations, and local authority having jurisdiction.

7. Documentation of system voltage, current, and resistance readings taken during installation, testing, and ATP phases of system installation.

8. System record drawings and wiring details including one set of reproducible masters and Drawings on CD-ROM in a DXF format suitable for use in a CAD drafting program.

9. NFPA 72, Record of Completion: Submit to Engineer and Owner.

10. NFPA 72, Inspection and Testing Form: Submit to Engineer and Owner.

1.06 QUALITY ASSURANCE

A. Qualifications:

1. Provide names of projects, locations, and telephone numbers of persons to contact for at least two installations where Contractor or Subcontractor has installed detection and alarm systems that are similar in size and scope as this.

2. System design, installation and testing shall be performed by licensed firm(s) with established reputation in fire alarm system industry having 5 years' experience in design, installation, and testing of fire alarm systems.

3. Technician with minimum of NICET Level II Certification for fire alarm systems or professional engineer registered in State of North Carolina shall be available onsite. (5) years documented experience installing and maintaining fire alarm system for similar installations.

B. Training Requirements:

1. On-site training shall include: a) variable changes b) programming changes c) report creations and changes d) system functional changes

2. Contractor shall provide 2 hours of on-site owner training to Owner personnel. Training to include hardware repair and maintenance of all building panels and devices, including but not limited to, diagnostic procedures, system expansion, and maintenance techniques.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Simplex

2. Honeywell Fire Alarm Systems

3. Edwards.

2.02 GENERAL

A. Material and equipment shall be standard products of their respective manufacturers, and shall be of a model that has been in production for not less than 3 years. Equipment shall be supported by a service organization that is, in the opinion of the Owner, reasonably convenient to the site.

B. Contractor shall become familiar with details of Project, verify dimensions in field, and revise conduit and equipment locations to avoid obstructions and allow installation of new equipment.

C. Contractor shall not begin system installation prior to receiving written approval of Shop Drawings from Engineer.

2.03 UL COMPLIANCE

A. Products manufactured within scope of Underwriters Laboratories, Inc. shall conform to UL Standards and have an applied UL listing mark.

B. Equipment shall be UL listed in accordance with requirements of NFPA.

2.04 SERVICE CONDITIONS

A. Altitude: Not greater than 3,300 feet above sea level.

B. Ambient Temperature:

1. Maximum 40 degrees C.

2. Minimum 0-degree C.

C. Equipment shall be fully rated without derating for these conditions.

2.05 FIRE ALARM CONTROL PANELS

A. Three (3) isolation modules for each addressable loop; two (2) at the FACP and one (1) midway through the loop address scheme.

2.06 INDIVIDUAL ALARM MODULE

A. Monitors single and multiple devices with dry contacts.

B. Suitable for installing inside 4-inch by 4-inch by 2-1/2-inch electrical box.

2.07 INITIATING DEVICE:

A. Pull Station, Fire:

1. Single-action station for general alarm.

2. Constructed of red molded polycarbonate material and raised white letters stating “FIRE.”

3. Surface-mounted in unfinished areas and semi-flushed finished areas with hinged front cover having keyed access; allen-wrench reset lock is not acceptable.

4. Recessed pull handle for single action push plate and pull handle for double action operating station with plastic break rod.

5. Activated station pull handle, latched in protruding position until reset by key.

6. Stations keyed alike with fire alarm control panel.

7. Screw terminal for field connections.

8. Normally open, Double-pole contacts rated 5 amperes, 125V ac for resistive loads.

B. Smoke Detectors:

1. Photoelectric type with plug-in, twist-lock base per UL 217 and UL268.

2. Concealed, field adjustable, sensitivity test switch.

3. LED; pulsed indication for power availability and steady indication for activated detectors.

4. Self-Compensating Circuitry:

5. Voltage Range: 15V dc to 30V dc, 24V dc nominal.

6. Temperature Range: 0 degrees C to 38 degrees C.

7. Operating Temperature Range: Minus 10 degrees C to 50 degrees C.

8. Humidity Range: 0 to 95 percent relative humidity.

9. Normally open, double-pole contacts, rated 3 amperes, 125V ac for resistive loads.

10. Magnet test capability for all smoke detectors.

C. Air Duct Smoke Detector:

1. Duct mounted housing with prealigned sampling and exhaust tubes, analog sensing, solid state circuitry, and plug-in, twist-lock base for photoelectric detector in accordance with UL 286A, NFPA 72, NFPA 90A, and NFPA 101.

2. Sampling tubes to extend full width of branch air return duct.

3. Self-Compensating Circuitry:

   a. Voltage Range: 15V dc to 30V dc, 24V dc nominal.
   b. Temperature Range: 0 degrees C to 38 degrees C.
   c. Humidity Range: 10 percent to 90 percent relative humidity.
   d. Velocity Range: 400 feet to 4,000 feet per minute.

4. Front mounted LED with pulsed indication for alarm condition.

5. Normally open, single-pole, double-throw auxiliary relay with 2 amperes, 125Vac rated contacts for resistive loads.

D. Detector Accessories:

1. Remote test station and power-on indicator with LED alarm indicator and two-position, key-operated switch for air duct smoke detectors.

2. Remote LED alarm indicator.

3. End-of-line device with normally open relay contacts for zone voltage monitoring.

2.02 WIRING

A. Low voltage wiring shall be solid copper or bunch tinned (bonded) stranded copper, minimum 14 AWG THHN, red and shall meet NEC Article 760 for manpower limited service. (Cable Type FPLR or FPLP).

B. Network or addressable loop cables shall be as recommended by manufacturer for installation of their system and UL Listed for Fire Alarm Systems.

2.03 RACEWAYS

A. Conduit used for installation of Fire Alarm system shall follow requirements as identified in Section 26 05 19, Low Voltage Electrical Power.

B. Compression type fittings for all conduit with insulated throats.

2.04 END-OF-LINE RESISTORS

A. Ohmic value and power rating as determined by manufacturer based upon number of circuit devices supplied and circuit configuration as installed.

PART 3 - EXECUTION

3.01 GENERAL

A. Coordinate with other trades for mounting and interfacing with fire alarm system related devices.

B. Existing system is to remain in operation until new system is fully installed, tested and operational throughout the entire facility. Changeover from existing to new system is to be scheduled in advance with the Owner at the Owner's convenience to minimize disruption to ongoing operations.

C. Install control panels, initiating devices, conduit, and wiring for interconnection of devices specified herein and for interconnection of flow and supervisory switches.

D. The Contractor shall conduct a mandatory pre-construction meeting with the electrical contractor, the fire alarm contractor.

3.02 INSTALLATION

A. Install and connect fire detection and alarm equipment in accordance with manufacturer's instructions and recommendations, and in accordance with applicable codes and standards.

B. Mount devices in accordance with manufacturer's instructions.

C. Provide outlet and junction boxes that are compatible with raceway system.

D. Mount detector LEDs so they are readily visible from floor.

E. Arrange sampling tubes and duct detectors to monitor duct area and point of duct penetration sealed and reinsulated.

F. Program or configure panels and devices, as required to operate as described herein. Operations.

G. Install conductors in accordance with Section 26 05 19, Building Wire and Cable, and NFPA 70, Article 760.

H. Circuit wiring color-code, as established by installer, to be maintained throughout installation.

I. Detectors shall not be installed until after construction clean up of trades is complete, per requirements of NFPA. Exception, where required by AHJ for protection during construction, detectors installed prior to final clean-up by trades shall be cleaned or replaced.

J. Duct Smoke Detector: Furnish, wire, and connect to fire alarm system in accordance with this Specification.

K. HVAC Equipment: Wire and connect fire alarm system to air handling unit system fan. Coordinate work with HVAC equipment supplied.

3.03 CONDUIT

A. Requirements apply to fire alarm system conduits, electrical enclosures, terminal cabinets, junction boxes, pullboxes, and device backboxes.

B. Conduit systems shall be dedicated to fire alarm system and shall contain no unrelated conductors.

C. Fire alarm system conduits shall be of sizes and types specified under Section 26 05 19, Building Wire and Cable.

1. Conduit shall be as identified under Division 26. Metallic conduit may be used for whips to devices only, maximum length 6 feet, 3/4-inch diameter minimum. Set screw type couplings or connectors are specifically prohibited.

2. Size conduits according to conductors contained therein. Cross sectional area percentage fill for fire alarm system conduits shall not exceed 40 percent.

D. Route and install conduit to minimize potential for physical damage, either mechanical or by fire, and so as not to interfere with existing building systems, facilities or equipment, and to facilitate service and minimize maintenance. Coordinate installation between different trades to avoid conflicts.

1. Conduit, except flexible conduit whips to devices, shall be solidly attached to building structural members or permanent walls. Conduit shall not be attached to existing conduit, ductwork, cable trays, other ceiling equipment, drop ceiling hangers/grids or partition walls, except where necessary to connect to initiating, evacuation signaling or auxiliary function devices.
2. Conduit shall be routed either parallel or perpendicular to building structural members.
3. Conduit shall be installed at a height so as not to obstruct any portion of a window, doorway cable tray, stairway or a passageway, and shall not interfere with operation of existing mechanical or electrical equipment.
4. Conduit, junction boxes, pull boxes, terminal cabinets, electrical enclosures and device backboxes shall be readily accessible for inspection, testing, service and maintenance.
5. Conduits shall be arranged to minimize the possibility of water in those conduits draining through control panels.
    a. Conduit, except nipples between control panels shall be arranged to enter control cabinets from below.
    b. Conduit shall be provided with three, 1/4-inch drain holes at horizontal low point beneath each control cabinet.
6. Bushings shall be provided at termination of conduit, prior to installation of wire.
7. Install junction boxes as necessary. Conductors shall be pulled through junction boxes, without splices.
8. Pullboxes shall be installed in each conduit at intervals not to exceed 100 feet. Pullboxes shall be 4-inch square, minimum.
9. Device backboxes and junction boxes shall be sized to accommodate number of conductors contained. Extension rings or extension boxes are prohibited.
10. Junction boxes, pull boxes, terminal cabinets, device backboxes, and raceways shall be gasketed and weather-tight per requirements of Section 26 05 24, Conduit.

E. Conduit, junction boxes, panels, electrical enclosures, relays and device backboxes shall be exposed in unfinished areas. Conduit and device backboxes shall be concealed in walls, ceiling spaces, electrical shafts or closets, in finished areas, except as noted on Drawings. Exposed conduit penetrations of walls shall be provided with escutcheon plates on either side of the wall.

F. Conduit penetrations of walls, floors and ceilings shall be sealed around conduit(s). Restoring walls, floors and ceilings to their original condition, fire resistance and integrity.

G. Pull boxes, junction boxes, conduit bodies, and terminal cabinets shall be painted “fire engine red” prior to installation. Provide touch-up painting, of normally visible pull boxes, junction boxes, and terminal cabinets prior to final acceptance testing.

H. Conduit shall be grounded by approved ground clamps, and per NEC requirements.

I. Mount end-of-line resistors on terminal blocks.

J. Detection and alarm wire shall be installed in separate conduits. Outgoing and return conductors for each supervised circuit shall be routed in separately as required by NFPA 72. The minimum separation of outgoing and return conduits shall be 1 foot vertically and 4 feet horizontally.

3.04 IDENTIFICATION

A. All device labels shall be made using an electronic labeling system with black letters on white background. Write-on labels are prohibited. Contractor shall provide a typed legend for all junction boxes and riser boxes corresponding to these labels. Legend shall be mounted in riser boxes. If system does not have riser boxes, contractor shall provide legend to Owner at time of Owner acceptance.

B. Junction, terminal, and pulling box covers shall be painted red and identified with engraved labels by loop number and circuit that it contains.

C. Detection and terminal devices shall have engraved alphanumeric identification that shall be keyed to posted operations and maintenance instructions. H. Labeling Requirements

D. Junction box covers shall be labeled as to their contents using an electronic labeling system with black letters on white background.

E. Contractor shall label all wires terminating in junction boxes and riser boxes. These labels shall be self-sticking wire numbers.

F. All initiating devices and modules for Intelligent Point Identification Device (P.I.D) systems shall be labeled with their addresses, including loop and point number.

3.05 CONDUCTORS

A. Requirements apply to fire alarm system conductors, including all signaling line, initiating device, indicating appliance, releasing function, remote signaling, ac and dc power and grounding/shield drain circuits.

B. Conductors shall be:

1. New; wire that has scrapes, nicks, gouges or crushed insulation shall not be used.
2. Installed in J-hooks or conduit.
3. Continuous between devices and between devices and intermediary terminal cabinets.

4. Low voltage conductors shall be minimum size No. 14 AWG. Smaller conductors shall only be permitted where part of a manufacturer's specific communications cable, i.e. addressable system.

C. Splices in conductors are specifically prohibited.

D. Types:

1. Conductors, except ac power conductors and grounding conductors, shall be solid copper or bunch tinned (bonded) stranded copper.

2. Stranded copper conductors are acceptable for ac power conductors and grounding conductors only.

E. Terminations, including field connections to supervisory resistors, diodes, relays or other devices shall be to numbered terminals or terminal strips and readily accessible for inspection, service, testing and maintenance.

1. Terminations shall be within junction boxes, device backboxes, terminal cabinets, control panels or other suitable metal enclosures.

2. Terminals and terminal strips shall be suitable for the size and number of conductors connected to them.

3. Each conductor termination shall be uniquely numbered with durable plastic tags or uniquely identifiable by a combination of numbers and color codes. These conductor numbers shall be shown on Contractor's Record Drawings (floor plans and detailed wiring diagrams) in a manner allowing ready identification of conductor terminations.

4. Wire nuts are prohibited.

5. Where pigtail devices are factory provided with wires too short to be connected to terminal strips (i.e., solenoids), such connections shall be soldered and taped.

F. Control Panel Wiring:

1. Fully dressed and bundled with nylon tie wraps at 3-inch intervals.

2. Bundled wiring shall be routed parallel to terminal strips within control panels, with individual conductors turned out at 90 degree angles to their associated terminal connections.

3. AC power conductors shall be bundled and routed separately from low voltage conductors. A minimum 2-inch separation shall be maintained between ac power conductors and low voltage conductors wherever possible.

4. Control cabinets shall be sized to accommodate the requirements of this Section.

5. Control panels shall not be used as raceways. Conductors that do not terminate within a control panel shall not be routed through that control panel.

G. Conductors shall be separated into the following categories:

1. Low voltage circuits that serve devices.

2. AC power circuits.

H. Each category of conductors shall be installed in physically separated, dedicated conduits, and shall not interface with one another, except at common associated control equipment. Conductors shall be further segregated as necessary to conform to fire alarm system manufacturer's recommendations and as necessary to prevent electrical crosstalk between conductors installed in common conduits.

I. Wiring shall be THHN-stranded. Use of multi-conductor twisted pair or similar wiring is not permitted.

J. Install as nonpower limited circuits in accordance with NFPA 72, and NEC, Article 760.

K. Conductors looped around terminals are prohibited.

L. Wire nut splices are prohibited.

M. T-tapping of circuits is prohibited.

N. Circuits shall be megger tested to voltage rating of their insulation before final terminations are made.

3.06 REPAIR/RESTORATION

A. Touchup scratches, mars, and dents, incurred during shipment or installation of equipment.

B. If required because of extensive damage, as determined by Engineer, refinish entire assembly.

C. Keep covers on smoke detectors until areas have been thoroughly cleaned.

3.07 TESTS AND INSPECTION (Entire Replacement System)

A. In accordance with NFPA 72, the Contractor shall conduct a mandatory pre-construction meeting with the electrical contractor, the fire alarm contractor and Owner.

B. Perform tests in presence of the Engineer and Owner Representatives.

C. Each smoke detector shall be individually field tested prior to installing device at its designated location to ensure reliability after shipment and storage conditions. A dated log indicating system address, type of device, sensitivity and initials of technician performing test, using test equipment specifically designed for that purpose, shall be prepared and kept for final acceptance documentation. After testing detection devices, base shall be labeled with system address, date, and initials of installing technician. Labeling shall not be visible after installation is complete.

D. Test wiring runs for continuity, short circuits, and grounds before system is energized. Resistance, current, and voltage readings shall be made as work progresses.

1. Systematic record shall be maintained of all readings using schedules or charts of tests and measurements. Areas shall be provided on logging form for readings, dates, and witnesses.

2. Notify Fire Marshal and Owner before start of any required tests. Correct items found at variance with Drawings or Specification during testing or inspection.

3. Deliver test reports to Fire Marshal and Owner as completed.

4. Test system wiring to demonstrate correct system response and correct subsequent system operation in event of:

   a. Open, shorted, and grounded intelligent analog signaling line circuit.
   b. Open, shorted, and grounded network signaling line circuit.
   c. Open, shorted, and grounded conventional initiating device circuits.
   d. Primary power or battery disconnected.
   e. Incorrect device address.

5. System indications shall be demonstrated as follows:

   a. Correct message display for each alarm input at control panel.
   b. Correct annunciator light for each alarm input, at control panel.

6. Demonstrate system onsite and offsite reporting functions as follows:

   a. Correct alarm custom message display, address, device type, date and time transmitted, for each alarm input.
   b. Correct trouble custom message display, address, device type, date and time transmitted, for each alarm input.
   c. Trouble signals received for disconnect.

7. Secondary power capabilities shall be demonstrated as follows:

   a. Disconnect system primary power for a period as specified herein; at end of period, alarm condition shall be created and system shall perform as specified for period as specified.
   b. Restore system primary power for 48 hours and system-charging current shall be normal trickle charge for fully charged battery bank.
   c. Check system battery voltages and charging currents at fire alarm control panel using test codes and LCD displays

E. In the event system fails to perform as specified and programmed during acceptance test, test shall be terminated at discretion of acceptance inspector.

1. Retest system, correcting deficiencies and providing test documentation to acceptance inspector.

2. In event that software changes are required during acceptance test, system manufacturer to compare edited program with original and shall furnish utility program. Utility shall yield printed list of changes and system functions, inputs and outputs affected by changes. Items listed by program shall be minimum acceptable to be retested before calling for resumption of acceptance test. Submit printed list and printer log of retesting before scheduling of acceptance test.

3. Acceptance inspector may elect to require complete acceptance test to be performed again if, in their opinion, modifications to system hardware or software warrant complete retesting.

F. Programming and Software Requirements

1. Contractor shall provide all software, hardware, interfaces, adapters, and cables required for all programming and maintenance functions.
2. If the contractor would normally use a laptop to program the system, a similar computer shall be supplied even if programming from the FACP keypad is available.
3. Contractor shall provide all software required for full system maintenance and upgrades to fire alarm system including any device changes, additions, or deletions.
4. Contractor shall provide all software updates during the warranty period and upgrades to software following the warranty period that address system operating failures or defects during the life of the system.
5. Contractor shall provide all levels of password access with documentation.

G. Upon completion of tests, complete and provide the following:

1. NFPA 72, Record of Completion, and Inspection and Testing Form.
2. Any special equipment, tools, and programming devices required for the operation, maintenance or repair of the installed fire alarm system.

H. Programming and Software Requirements

1. Contractor shall provide all software, hardware, interfaces, adapters, and cables required for all programming and maintenance functions.
2. If the contractor would normally use a laptop to program the system, a similar computer shall be supplied even if programming from the FACP keypad is available.
3. Contractor shall provide all software required for full system maintenance and upgrades to fire alarm system including any device changes, additions, or deletions.
4. Contractor shall provide all software updates during the warranty period and upgrades to software following the warranty period that address system operating failures or defects during the life of the system.
5. Contractor shall provide all levels of password access with documentation.

I. System outages for occupied buildings:

1. The Contractor shall notify Owner prior to any work to contacts/interface with any alarm detection devices (smoke detectors, pull stations, horns, panels, etc.). If any disabling, disconnection, reconnection of fire alarm system equipment is necessary, the Contractor shall notify Owner at least five (5) working days prior to proposed work. Work cannot proceed until Contractor receives written approval from Owner.
2. Disabling or disconnection shall be limited to one (1) working day per outage. The Contractor shall be liable for any costs, direct or indirect, due to false alarms resulting from Contractor's work.

J. Air handling units controlled by FACP shall be de-energized directly by the FACP during alarm shutdowns. Fire alarm device relays and Building Automation Systems shall not be used for alarm shutdowns of air handling systems.

K. Spare Parts:

1. Fuses-two (2) of each size used in the installed system.
2. MPS-w/ monitor modules – Minimum one (1) or 2% of total installation.
3. Audio-visual devices – Minimum one (1) or 4% of total installation.
4. Indoor strobe only devices – Minimum one (1) or 4 % of total installation.
5. Exterior indicating devices – Minimum one (1) or 2% of total installation.
6. Spot Smoke Detectors – Minimum one (1) or 6% of total installation.
7. Spot heat/thermal detectors – Minimum one (1) or 6% of total installation.
8. Spot detector bases – Minimum one (1) or 2% of total installation.
9. Spot detector sounder bases – Minimum one (1) or 6% of total installation.
10. Relay modules – Minimum one (1) or 4% of each total installation.
11. Monitor modules – Minimum one (1) or 4% of total installation.
12. Isolation modules – Minimum one (1) or 4% of total installation.

L. Documentation:

1. Documentation provided shall be complete and provided to Owner at the time of acceptance, and shall include all necessary information to support the above stated functions. Manuals shall be bound, and published, consisting of the following:
2. Installation Manual.
3. Operator/User’s Manual.
4. Technical Manual.
5. Programming Manual.

END OF SECTION

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SECTION 31 10 00

SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Removing surface debris.
2. Removing designated trees, shrubs, and other plant life.

1.2 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Product Data: Submit data for herbicide. Indicate compliance with applicable codes for environmental protection.

1.3 QUALITY ASSURANCE

A. Conform to applicable code for environmental requirements, disposal of debris, burning debris on site, and use of herbicides.

B. Perform Work in accordance with of state transportation standards.

C. Perform Work in accordance with State Department of Environmental Quality standards. The Contractor shall ensure required permits are in place prior to commencing work.

PART 2 - PRODUCTS – Not Used

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify existing plant life designated to remain is tagged or identified.

C. Identify waste area for placing removed materials.

3.2 PREPARATION

A. Call Local Utility Line Information service at 811 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

3.3 PROTECTION

A. Locate, identify, and protect from damage utilities indicated to remain.

B. Protect trees, plant growth, and features designated to remain, as final landscaping as specified in Section 015000 - Temporary Facilities and Controls.

C. Protect benchmarks, survey control points, and existing structures from damage or displacement.

3.4 CLEARING

A. Clearing shall consist of the cutting and removal of all trees, brush, logs, hedges, the removal of fences and other loose or projecting material from the designated areas. Trees, stumps, and brush shall be cut a minimum of six inches (6”) from the ground surface.

B. The Contractor shall clear the indicated area of all materials as indicated on the plans. Trees unavoidably falling outside the specified clearing limits must be cut up, removed, and disposed of in a satisfactory manner. To minimize damage to trees that are to be left standing, trees shall be felled toward the center of the area being cleared. The Contractor shall preserve and protect from injury all trees not to be removed.

C. Clear areas as indicated on the Drawings.

D. Clear undergrowth and deadwood, without disturbing soil.

E. Apply herbicide to remaining stumps to inhibit growth.

3.5 REMOVAL AND DISPOSAL

A. Contractor shall coordinate in accordance with Owner’s agreement regarding any material that can be commercially salvaged.

B. All materials removed by clearing shall be disposed of outside the project limits at the Contractor’s responsibility, except when otherwise directed by the Engineer.

C. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.

D. Do not burn or bury materials on site. Leave site in clean condition.

SECTION 31 22 13

ROUGH GRADING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating topsoil.
2. Excavating subsoil.
3. Stockpiling materials.
4. Cutting, grading, filling, rough contouring, and compacting, site.

1.2 REFERENCES

A. ASTM International:

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3).
3. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
4. ASTM D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
5. ASTM D2434 - Standard Test Method for Permeability of Granular Soils (Constant Head).
6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Material Test Reports: For each on-site and borrow soil material proposed for use as follows:
1. Classification according to ASTM D2487.
2. Laboratory compaction curve according to ASTM D698.
3. Submit test results within 24-hours after testing is completed.

C. Materials Source: Obtain materials from same source throughout.

D. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E329 and ASTM D3740 for testing indicated.

1.4 CLOSEOUT SUBMITTALS

A. Section 017800 - Closeout Procedures: Requirements for submittals.

B. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with ASTM C136, ASTM D2419, and ASTM D2434.

B. Perform Work in accordance with authorities having jurisdiction requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Fill and Backfill: Where suitable, use existing onsite excavated satisfactory soils free from rubbish, debris, organic material, frozen material, or other objectionable materials.

C. Topsoil: Top 6 inches of existing onsite soil.

D. Satisfactory Soils: Soil Classification Groups CL, SC, ML, GW, GP, GM, SW, SP, and SM according to ASTM D2487, or combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

E. Unsatisfactory Soils: Soil Classification Groups GC, OL, CH, MH, OH, and PT according to ASTM D2487, or combination of these groups. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

F. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.

G. Base Course: In accordance with Section 32 11 23.

H. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.

I. Drainage Course: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing 1-1/2-inch sieve and zero to 5 percent passing No. 8 sieve.

J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing 1-inch sieve and zero to 5 percent passing No. 4 sieve.

K. Sand: ASTM C33; fine aggregate.

L. Impervious Fill: Clayey gravel and sand mixture capable of compacting to dense state.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify site conditions and report any deviations from the plan drawings to the Engineer within 48 hours of discovery.

B. Verify survey benchmark and intended elevations for the Work are as indicated on Drawings.

3.2 PREPARATION

A. Call Local Utility Line Information service at 811 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Identify required lines, levels, contours, and datum.

C. Notify utility company to remove and/or relocate utilities as indicated on the plan drawings.

D. Protect utilities indicated to remain from damage.

E. Protect plant life, lawns, and other features remaining as portion of final landscaping.

F. Protect benchmarks, survey control point, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

3.3 TOPSOIL EXCAVATION

A. Excavate topsoil from areas to be further excavated, relandscaped, or regraded, and as indicated on the plan drawings, without mixing with foreign materials for use in finish grading.

B. Do not excavate wet topsoil.

C. Stockpile in areas designated on site and in accordance with §3.5 below. Stockpile material until reuse or removal/disposal.

D. Remove excess topsoil not intended for reuse, from site.

3.4 SUBSOIL EXCAVATION

A. Excavate subsoil from areas to be further excavated, relandscaped, or regraded.

B. Do not excavate wet subsoil.

C. When excavating through roots, perform Work by hand and cut roots with sharp axe.

D. Remove excess subsoil not intended for reuse, from site.

E. Stability: Replace damaged or displaced subsoil as specified for fill.

3.5 STOCKPILING

A. Stockpile excavated material meeting requirements for subsoil and/or topsoil materials.

B. Stockpile materials on Site at locations as indicated or designated by Engineer.

C. Stockpile in sufficient quantities to meet Project schedule and requirements.

D. Separate differing materials with dividers or stockpile apart to prevent intermixing of soil types or contamination.

E. Stockpile in areas designated on site to depth not exceeding 35 feet and protect from erosion. Stockpile material until reuse or removal/disposal.

F. Direct surface water away from stockpile to prevent erosion or deterioration of materials.

G. Stockpile hazardous materials on impervious material and cover to prevent erosion and leaching until they are disposed.

3.6 FILLING

A. Fill areas to contours and elevations with unfrozen materials.

B. Place material in continuous layers as follows:

1. Subsoil Fill: Maximum 8 inches compacted depth.
2. Structural Fill: Maximum 8 inches compacted depth.
3. Granular Fill: Maximum as indicated on the Plan Drawings.

C. Maintain optimum moisture content of fill materials to attain required compaction density.

D. Slope grade away from building minimum 5 percent slope for minimum distance of 10 ft, unless noted otherwise.

E. Make grade changes gradual. Blend slope into level areas.

F. Repair or replace items indicated to remain that were damaged by excavation or filling. Repair and replacement shall be at Contractor's expense and to the satisfaction of the Owner and Engineer.

G. Install Work in accordance with authorities having jurisdiction standards.

3.7 TOLERANCES

A. Top Surface of Subgrade: Plus or minus 1/10-foot from required elevation.

3.8 FIELD QUALITY CONTROL TESTING AND ACCEPTANCE

A. Section 017800 - Closeout Procedures: Field inspecting, testing, adjusting, and balancing.

B. Perform laboratory material tests in accordance with ASTM D698 or Geotechnical Engineer's recommendations. Geotechnical Engineer's recommendation shall govern testing requirements.

C. Perform in place compaction tests in accordance with the following:

1. Density Tests: In accordance ASTM D1556, ASTM D6938 or Geotechnical Engineer's recommendations. Geotechnical Engineer's recommendation shall govern testing requirements. or.
2. Moisture Tests: ASTM D3017.

D. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

E. Frequency of Tests:
1. Under Structures, Building Slabs, Steps, and Pavements: At least one test per 1,000 square feet or less, but no fewer than three tests.
2. Under Walkways: At least one test per 1,000 square feet or less, but no fewer than three tests.
3. Under Turf or Unpaved Areas: Random tests, as necessary.
4. In accordance with Geotechnical Engineer's recommendations. Geotechnical Engineer's recommendation shall govern frequency of testing.

F. Test Acceptance
1. Backfill and Fill Acceptance:
   a. Under Structures, Building Slabs, Steps, and Pavements: 100 percent of maximum laboratory density.
   b. Under Walkways: 95 percent of maximum laboratory density.
   c. Under Turf or Unpaved Areas: 90 percent of maximum laboratory density.
2. Filter Material Acceptance: 95 percent of maximum laboratory density.
3. Subbase Course Acceptance: 100 percent of maximum laboratory density.
4. Drainage Course Acceptance: 100 percent of maximum laboratory density
5. If tests indicate Work is not acceptable, re-compact and retest. If necessary, remove and replace Work.

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SECTION 31 23 16

TRENCHING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating trenches for utilities from 5 feet outside building to utility service.
2. Backfilling and compaction.

1.2 REFERENCES

A. ASTM International:

1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3.
2. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
3. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
4. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 DEFINITIONS

A. Backfill: Soil material or flowable fill used to fill an excavation after placement of bedding course, utility, and embedment material.

B. Initial Backfill: Backfill placed beside and over pipe in trench, including haunches to support sides of pipe.

C. Final Backfill: Backfill placed over initial backfill to fill trench.

D. Bedding Course: Aggregate layer placed over excavated subgrade in trench before laying pipe.

E. Borrow Soil: Satisfactory soil imported from off-site for use as backfill.

F. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1-cubic yard for bulk excavation or ¾-cubic yard for footing, trench, and pit excavation that cannot be removed by rock-excavating equipment equivalent to following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted.

G. Blastable Rock: Partially weathered rock materials with penetration resistances higher than 50 blows per 2 inches of penetration.

H. Rippable Rock: Partially weathered rock materials with penetration resistances no higher than 50 blows per 2 inches of penetration. To be ripped with a large dozer such as a CAT D8 or equivalent equipped with a single tooth ripper.

I. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with 42-inch maximum-width, short-tip-radius rock bucket; rated at not less than 138-horsepower flywheel power with bucket-curling force of not less than 28,700-pound-foot and stick-crowd force of not less than 18,400-pound-foot with extra-long reach boom. Ratings are based on Caterpillar's Model No. 320CL or Model No. 320DL.

J. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-horsepower flywheel power and developing minimum of 47,992-pound-foot breakout force with general-purpose bare bucket. Ratings are based on Caterpillar's Model No. 973C.

K. Soil Classification: ASTM D2487.

L. Subgrade: Uppermost surface of excavation or top surface of fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

M. Utility: Any buried pipe, duct, conduit, cable, underground service to buildings, and associated appurtenances.

1.4 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Product Data: Submit manufacturer’s product data for marker tape.

C. Material Test Reports: For each on-site and borrow soil material proposed for bedding, embedment, and backfill as follows:
   1. Classification according to ASTM D2487.
   2. Laboratory compaction curve according to ASTM D698.
   3. Submit test results within 24-hours after testing is completed.

D. Materials Source: Obtain materials from same source throughout.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with authorities having jurisdiction.

1.6 QUALIFICATIONS

A. If required, prepare excavation protection plan under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of North Carolina.

1.7 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.8 COORDINATION

A. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Fill and Backfill: Where suitable, use existing onsite excavated satisfactory soils free from rubbish, debris, organic material, frozen material, or other objectionable materials.

C. Topsoil: Top 6 inches of existing onsite soil.

D. Satisfactory Soils: Soil Classification Groups CL, SC, ML, GW, GP, GM, SW, SP, and SM according to ASTM D2487, or combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

E. Unsatisfactory Soils: Soil Classification Groups GC, OL, CH, MH, OH, and PT according to ASTM D2487, or combination of these groups. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

F. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.

G. Base Course: In accordance with Section 32 11 23.

H. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.

I. Drainage Course: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing 1-1/2-inch sieve and zero to 5 percent passing No. 8 sieve.

J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing 1-inch sieve and zero to 5 percent passing No. 4 sieve.

K. Sand: ASTM C33; fine aggregate.

L. Impervious Fill: Clayey gravel and sand mixture capable of compacting to dense state.

PART 3 - EXECUTION

3.1 LINES AND GRADES

A. Lay pipes to lines and grades indicated on Drawings.

1. Engineer and Owner reserve right to make changes in lines, grades, and depths of utilities when changes are required for Project conditions.

B. Use laser-beam instrument with qualified operator to establish lines and grades.

3.2 PREPARATION

A. Call Local Utility Line Information service at 811 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Identify required lines, levels, contours, and datum locations.

C. Protect plant life, lawns, and other features remaining as portion of final landscaping.

D. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

E. Maintain and protect above and below grade utilities indicated to remain.

F. Establish temporary traffic control and detours when trenching is performed in public right-of-way. Relocate controls and reroute traffic as required during progress of Work.

3.3 TRENCHING

A. Excavate subsoil required for utility installation.

B. Remove lumped subsoil, boulders, and rock.

C. Perform excavation within 24 inches of existing utility service in accordance with utility's requirements.

D. Do not advance open trench more than 60 feet ahead of installed pipe.

SECTION 32 11 23

AGGREGATE BASE COURSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aggregate subbase.
2. Aggregate base course.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.

B. ASTM International:

1. ASTM D2940 - Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports.

C. North Carolina Department of Transportation (NCDOT):

1. NCDOT Standard Specifications for Roads and Structures (NCDOT Specifications):
   a. Section 520 - Aggregate Base Course.
   b. Section 1010 - Aggregate for Non-Asphalt Type Bases.

1.3 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Product Data:

1. Submit data for geotextile fabric and herbicide.

C. Materials Source: Submit name of aggregate materials suppliers.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

E. Prior to Production:

1. Identify aggregate source.
2. Submit test results indicating aggregate meets material requirements of NCDOT Specifications.
3. Submit job-mix gradation indicating single value for each sieve size required.

F. Changes to Job-Mix Gradation: Submit in writing prior to start of day's production. Changes are subject to approval.

G. Submit quality control test results within 24 hours after testing is completed.

1.4 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

B. Perform Work according to NCDOT of standards.

PART 2 - PRODUCTS

2.1 AGGREGATE MATERIALS

A. Aggregate Base Course: Well-graded, clean, hard, tough, durable, and sound mineral aggregates consisting of crushed stone, crushed gravel, or crushed slag; free of organic matter and contamination from chemical or petroleum products; meeting the requirements of Division 10 within the NCDOT Standard Specifications for Roads and Structures.

2.2 ACCESSORIES

A. Geotextile Fabric: AASHTO M288; non-woven, polypropylene.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify compacted substrate is dry and ready to support paving and imposed loads.

1. Proof roll substrate with 20-ton tandem axle dual wheel dump truck loaded to the legal limit with the tires inflated to 100 psi in minimum in two perpendicular passes to identify soft spots. Proof roll shall be done in the presence of the RPR and/or authorities having jurisdiction.
2. Soft areas of the substrate that deflect more than 1 inch or show permanent deformations greater than 1 inch shall be removed and replaced with suitable materials or reworked to conform to the moisture content and compactions requirements in accordance with these specifications. Remove soft substrate and replace with compacted fill as specified in Section 312323.

B. Verify substrate has been inspected, gradients and elevations are correct.

3.2 PREPARATION

A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.

B. Do not place fill on soft, muddy, or frozen surfaces.

C. Do not place aggregate base course until subgrade is accepted by Engineer or authorities having jurisdiction.

3.3 AGGREGATE PLACEMENT

A. Install geotextile fabric over subgrade according to manufacturer's instructions.

1. Lap ends and edges minimum 6 inches.
2. Anchor fabric to subgrade when required to prevent displacement until aggregate is installed.

B. Spread aggregate over prepared substrate and compact in accordance with NCDOT Specifications.

C. Roller compact aggregate to 95 percent maximum density.

D. Level and contour surfaces to elevations, profiles, and gradients indicated.

E. Add small quantities of fine aggregate to coarse aggregate when required to assist compaction.

F. Maintain optimum moisture content of fill materials to attain specified compaction density.

G. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.4 TOLERANCES

A. Maximum Variation From Flat Surface: 1/4 inch measured with 10 foot straight edge.

B. Maximum Variation From Thickness: 1/4 inch.

C. Maximum Variation From Elevation: 1/2 inch.

3.5 FIELD QUALITY CONTROL

A. Section 017800 - Closeout Procedures: Field inspecting, testing, adjusting, and balancing.

B. Compaction testing will be performed according to NCDOT Specifications.

C. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

D. Frequency of Tests: In accordance with NCDOT Specifications.

3.6 COMPACTION

A. Compact materials to 98 percent of maximum density as determined from test strip, according to ASTM D2940.

SECTION 32 12 16

ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Asphalt materials.
2. Aggregate materials.
3. Aggregate subbase.
4. Asphalt paving base course, binder course, and wearing course.
5. Asphalt paving overlay for existing paving.
6. Surface slurry.

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials:
1. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.
2. AASHTO M320 - Standard Specification for Performance-Graded Asphalt Binder.

B. North Carolina Department of Transportation (NCDOT):
1. NCDOT Standard Specifications for Roads and Structures (NCDOT Specifications):
   a. Section 600 – Prime Coat.
   b. Section 605 – Asphalt Tack Coat.
   c. Section 607 – Milling Asphalt Pavement.
   d. Section 609 – Quality Management System for Asphalt Pavements.
   e. Section 610 – Asphalt Concrete Plant Mix Pavements.
   f. Section 620 - Asphalt Binder for Plant Mix.
   g. Section 657 - Sealing Existing Pavement Cracks and Joints.

C. NCDOT Asphalt Quality Management System, Materials and Tests Unit, Asphalt QMS Manual (QMS Manual), latest edition.

1.3 DEFINITIONS

A. Lot: Number of tons of asphalt pavement placed in production day.

B. Minor Target Change: Change from verified mix design gradation target on maximum of two sieves with limitations as follows:
1. Maximum allowable change in target gradation on #8 or any coarser sieve is limited to 3 percent passing per sieve.

2. Maximum allowable change in target gradation on #16 or #50 sieves is 2 percent passing per sieve.
3. Maximum allowable change in target gradation on #200 sieve is 0.5 percent passing.
4. No target change may violate mix design requirements.

C. Non-Permeable Asphalt Pavement: Asphalt pavement that water will not penetrate through mix when water is placed on surface of pavement.

D. Production Day: 24-hour period in which asphalt pavement is being placed.

E. Screed: Any strike-off device operated by cutting, crowding or other practical action which is effective on mixture at workable temperature without tearing, shoving or gouging and which produces finished surface of evenness and texture specified.

1.4 COORDINATION

A. Prepare weekly schedule detailing construction activities planned for following week. Present schedule to RPR before Friday, 12:00 pm (noon) of preceding effective date of schedule. Weekly meetings may be required to review construction activities as indicated by Engineer.

1.5 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Product Data:

1. Submit product information for asphalt and aggregate materials.
2. Submit mix design with laboratory test results supporting design.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

D. Mix design: Submit at least 10 days before paving begins.
1. Include test data used to develop mix design.
2. Indicate single value for percentage of aggregate passing each sieve and asphalt cement content. Provide gradation within each band indicated.

E. Changes to Mix Design: Submit in writing prior to production.

F. Corrective action plan according to requirements of this Section.

G. Weigh Tickets: Submit to Engineer at end of each workday. Keep duplicate copy of tickets.

H. Sample: Provide sample to Engineer for calibration of burn off oven.

1.6 QUALITY ASSURANCE

A. Mixing Plant: Conform to NCDOT standards.

B. Obtain materials from same source throughout.

C. Perform Work in accordance with NCDOT standards.

1.7 QUALIFICATIONS

A. Installer: Company specializing in performing work of this section listed on NCDOT approved list.

1.8 AMBIENT CONDITIONS/LIMITATIONS

A. Section 015000 - Temporary Facilities and Controls: Ambient conditions control facilities for product storage and installation.

B. Do not place asphalt mixture between months specified in NCDOT Specifications/QMS Manual.

C. Do not place asphalt mixture when ambient air or base surface temperature is less than 40 degrees F, or surface is wet or frozen.

D. Do not place asphalt pavement when base has free surface water, base is oversaturated, or frozen.

E. Do not place asphalt pavement during adverse weather conditions such as precipitation. If precipitation begins during paving operations, Owner assumes no responsibility for asphalt left in trucks when paving operation is halted due to precipitation.

F. Use release agent that does not dissolve asphalt and is acceptable to Engineer for equipment and hand tools used to mix, haul, and place asphalt pavement.

G. Provide and have ready for use, at all times, enough tarpaulins or covers in case of precipitation or other delay, for covering or protecting any material dumped but not spread.

PART 2 - PRODUCTS

2.1 ASPHALT PAVING

A. Performance / Design Criteria:

B. Asphalt Materials:

1. Asphalt Surface/Binder/Intermediate Courses: AASHTO M320; performance grade PG 64-22 in accordance with NCDOT Specifications/QMS Manual.
    a. Type: As listed on the Plan Drawings.
    b. Depth: As listed on the Plan Drawings.
2. Warm Mix: In accordance with NCDOT standards.

3. Primer: In accordance with NCDOT standards.
4. Tack Coat: In accordance with NCDOT standards.
5. Reclaimed Asphalt Pavement (RAP): Processed material obtained by milling or full depth removal of existing asphalt paving.
6. Oil: In accordance with of NCDOT standards.

C. Aggregate Materials:
1. Coarse Aggregate: In accordance with NCDOT standards.
2. Fine Aggregate: In accordance with NCDOT standards.
3. Mineral Filler: In accordance with NCDOT standards.

D. Aggregate Subbase: Specified in Section 321123.

2.2 MIXES

A. Use dry material to avoid foaming. Mix uniformly.

B. Asphalt Paving Mixtures: Designed in accordance with NCDOT standards. Maximum percent by weight of reclaimed asphalt pavement in accordance with NCDOT standards.

1. Base Course: Type and depth indicated on the Plan Drawings.
2. Binder Course: Type and depth indicated on the Plan Drawings.
3. Wearing Course: Type and depth indicated on the Plan Drawings, if applicable.

2.3 EQUIPMENT

A. Asphalt Paver: Use self-propelled paver with screed capable of spreading mixture without segregation, placing to required grade, and confining mixture to true lines without use of stationary side forms. Paver must be equipped with acceptable automatic control system, which controls longitudinal grade and transfer slope, except when paving miscellaneous areas or when Engineer determines use of automatic control system is impractical. Use pick up conveyor or shuttle buggy to transfer asphalt mix from windrow to paver.

B. Asphaltic Mixture Hauling Vehicles: Use trucks with tight clean and smooth boxes. End-Dump type vehicles are prohibited from dumping directly into paver.

C. Rollers: Use rubber tire and steel self-propelled rollers in sufficient number to keep up with paver. Use release agent other than diesel. Use tandem rollers of 8- or 10-ton model weighing not less than 250 pounds per inch width of roller tread. Provide sufficient number and weight of rollers to compact mixture to required density while still in workable condition. Slurries used for surface repair contain fine aggregate. Type 1 is finest mix designed to penetrate surface cracks. Type 3 is coarsest used to build new wearing surface or to build crown. Use Type 2 to repair surface erosion and fill surface voids and build minimum wearing surface.

2.4 VOLUMETRIC DESIGN

A. Perform Superpave Volumetric Mix Design according to NCDOT Standards and as follows:

1. Determine optimum asphalt content by test data curves.
2. Use test samples containing 0.5 percent increments of asphalt content.
3. Include minimum of 2 test samples above and below optimum asphalt content.

B. Mix Design Requirements:
1. Hamburg Wheel Tracker: Maximum 10 mm impression at 20,000 passes.
2. Number of Gyrations:
   a. N-initial = 7.
   b. N-design = 75.
   c. N-final = 115.
3. Air Voids: 3 percent.
4. Voids in Mineral Aggregate (VMA):
   a. ¾ Inch Mix: 13.0% - 14%.
   b. ½ Inch Mix: 14.0% - 15.0%.
   c. 3/8 Inch Mix: 15.0% - 16.0%.
5. Voids Filled with Asphalt (VFA): 70-80.

C. If material source changes, develop new mix design prior to using new materials.

D. Mix materials at central mixing plant. Use shortest mixing time needed to uniformly coat aggregate. Do not use material not mixed properly.

E. Adjust production at mixing plant and delivery to maintain steady paving speed.

F. Mix Design Changes:
1. Engineer may allow up to two minor target changes per project without penalty to contractor.

2.5 ACCESSORIES

A. Geotextile Fabric: AASHTO M288; non-woven, polypropylene.

B. Sealant: In accordance with NCDOT standards.

2.6 SOURCE QUALITY CONTROL

A. Submit proposed mix design of each class of mix for review prior to beginning of Work.

B. Test samples in accordance with NCDOT standards.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 017800 - Closeout Procedures: Requirements for installation examination.

B. Verify utilities indicated under paving are installed with excavations and trenches backfilled and compacted.

C. Verify compacted subgrade, granular stabilized soil and/or subbase is dry and ready to support paving and imposed loads.
   1. Proof roll subbase with 20-ton tandem axle dual wheel dump truck loaded to the legal limit with the tires inflated to 100 psi in minimum in two perpendicular passes to identify soft spots. Proof roll shall be done in the presence of the RPR or authorities having jurisdiction.
   2. Soft areas of the substrate that deflect more than 1 inch or show permanent deformations greater than 1 inch shall be removed and replaced with suitable materials or reworked to conform to the moisture content and compactions requirements in accordance with these specifications. Remove soft substrate and replace with compacted fill as specified in Section 312323.

D. Verify gradients and elevations of base are correct. Do not place asphalt concrete pavement until base course has been accepted by Engineer.

E. Verify gutter drainage, grates and frames, manhole lids and frames and other utilities are installed in correct position and elevation.

F. If Project is located near signalized intersection, contact NCDOT Division Traffic Engineer to schedule field location of traffic signal conflicts. Notify Engineer of any potential conflict prior to construction. Coordinate conflict relocation with NCDOT during construction.

3.2 PREPARATION

A. Prepare subbase in accordance with NCDOT standards and these specifications.

B. Do not start work until traffic control measures are in place.

C. Locate and reference utility covers prior to paving operations.

3.3 DEMOLITION

A. Where new pavement joins existing pavement, saw cut edge of existing pavement. Provide saw cut through full depth of pavement and in straight line. If pavement is cracked, broken or deteriorated, make saw cut so defective area is removed. Properly dispose of pavement removed by saw cutting. Remove dirt, sand, weeds, leaves, and other objectionable materials from prepared surfaces.

B. Remove and dispose of existing portland cement concrete or asphalt pavement structure, including paved shoulders, within limits shown on Drawings or as indicated by Engineer. Remove and dispose of temporary roadway pavement structure placed for detours.

C. Clean existing paving to remove foreign material, excess joint sealant and crack filler from paving surface.

D. Where indicated, mill asphalt pavement in accordance with Section 607 of NCDOT Standards

E. Where indicated, mill asphalt pavement in accordance with Section 607 of NCDOT Standards

F. Repair surface defects in existing paving to provide uniform surface to receive new paving.

3.4 INSTALLATION

A. Subbase:
   1. Prepare subbase in accordance with NCDOT standards and Section 321123.

B. Primer:

   1. Apply primer in accordance with NCDOT standards.
   2. Use clean sand to blot excess primer.

C. Tack Coat:

   1. Apply tack coat in accordance with NCDOT standards.

   2. Apply tack coat to contact surfaces of curbs, gutters and existing asphalt.
   3. Coat surfaces of manholes, catch basins and other utility frames with oil to prevent bond with asphalt paving. Do not tack coat these surfaces.

D. Single Course Asphalt Paving:

   1. Install Work in accordance with NCDOT standards.
   2. Place asphalt within 24 hours of applying primer or tack coat.
   3. Place asphalt wearing course to thickness indicated on Drawings.
   4. Compact paving by rolling to specified density. Do not displace or extrude paving from position. Hand compact in areas inaccessible to rolling equipment.
   5. Perform rolling with consecutive passes to achieve even and smooth finish without roller marks.

E. Double Course Asphalt Paving:

   1. Install Work in accordance with NCDOT standards.

   2. Place asphalt binder course within 24 hours of applying primer or tack coat.
   3. Place binder course to thickness indicated on Drawings.
   4. Place wearing course within 24 hours of placing and compacting binder course. When binder course is placed more than 24 hours before placing wearing course, clean surface and apply tack coat before placing wearing course.
   5. Place wearing course to thickness indicated on Drawings.
   6. Compact each course by rolling to specified density. Do not displace or extrude paving from position. Hand compact in areas inaccessible to rolling equipment.
   7. Perform rolling with consecutive passes to achieve even and smooth finish, without roller marks.

F. Asphalt Paving Overlay

1. Apply tack coat to existing paving surface at rate recommended by geotextile fabric manufacturer.
2. Install Work in accordance with NCDOT standards.
3. Install geotextile fabric in accordance with manufacturer's instructions to permit asphalt saturation of fabric. Lap fabric edge and end joints 4 inches.
4. Place wearing course to thickness indicated on Drawings.

G. Compact overlay by rolling to specified density. Do not displace or extrude paving from position. Hand compact in areas inaccessible to rolling equipment.

H. Perform rolling with consecutive passes to achieve even and smooth finish, without roller marks.

I. Curbs:

1. Install extruded asphalt curbs of as indicated on Drawings.

J. Joints:
1. Make in careful manner to provide well bonded and sealed joints.
2. Apply tack coat as indicated. If necessary, heat joint.
3. Offset longitudinal joints 6 to 12 inches in succeeding courses.
4. Place top course joint within one foot of roadway centerline or lane line.
5. Offset transverse construction joints at least 6 feet.
6. For roller breakdown pass on confined edge, keep 6 inches from confined edge on hot side of mat to ensure joint density.
7. For roller breakdown pass on unconfined edge, overlap unconfined edge at least 6 inches off of mat to prevent pavement from spreading.
8. Compact joint density to at least 90 percent of rice density.
9. Overlap screed onto previously placed mat ¾ to 1 inch maximum.
10. Do not rake longitudinal joint.

K. Compaction:
1. Start rolling as soon as mixture will bear roller without undue misplacement or hairline cracking. Delays in rolling hand raked mixture will not be tolerated.
2. Operate rollers with competent, experienced operator and kept in continuous operation as nearly as practicable.
3. Start rolling longitudinally at outer edges and proceed toward center of pavement, overlapping on successive trips by at least one-half width of roller.
4. Operate roller slow enough to avoid displacement mixture as a result of reversing. Correct any displacement immediately.
5. Roll at rate not in excess of 500 square yards per hour per roller and continue until no further visible compaction is obtainable and roller marks have been eliminated.
6. To prevent adhesion of mixture to roller, keep wheels moistened with water.
7. In places not accessible to roller, compact thoroughly with hot tampers.
8. Provide compaction and density control of asphalt in accordance with of Sections 609 and 610 of NCDOT Standards.

L. Where exposed to traffic, taper end of course at approximately 50:1 (horizontal to vertical).
   1. Remove portion of course that contains tapered end before placing fresh hot mix asphalt.
   2. Apply tack coat to contact surfaces of first course before fresh hot mix asphalt is placed against first course.

M. Hand rake only when necessary.

N. Set up exposed longitudinal edges of surface course by tamping with rake or lute at proper height and level to receive maximum compression under rolling.

O. Place asphalt pavement to provide slope for drainage.

P. Where indicated on Drawings, construct speed humps and/or raised crosswalks. Do not exceed maximum elevation indicated.

Q. Utility Adjustments:
   1. Adjust top of utility covers to match finish grade of asphalt pavement.
   2. Do not raise manhole or valve boxes for more than 14 days prior to resurfacing street.
   3. Immediately after making utility adjustment, paint sides of utility bright orange. Where necessary, place reflective orange traffic cones with 36-inch minimum height on utility.
   4. Notify Owner if any broken manhole ring and cover, or valve boxes are discovered.

3.5 PAVEMENT REPAIR PATCH

A. Where necessary to open cut along or across streets with asphalt surfaces, replace pavement with asphalt concrete intermediate course and asphalt concrete surface course to thickness indicated on Drawings.

B. Extend replacement of base and asphalt pavement minimum of 1 foot on each side of excavated opening. Provide replacement material thickness sufficient to provide base and asphalt pavement of equivalent strength to undisturbed base and asphalt pavement.

C. Meet applicable material and installation requirements.

3.6 CEASE PRODUCTION

A. Cease production when any two out of three consecutive lots meet one of the following criteria:
   1. Air voids at N-design averaged for each lot are less than 2.5 or greater than 4.75 percent.
   2. VMA at N-design averaged for each lot are not within plus or minus 1.25 percent of target value.

B. Submit corrective action plan to Engineer before production continues indicating changes in production procedures that will be implemented to correct deficiencies. Address specific issues contributing to cease production directive. Submit for Engineer to review and accept revised plan before production continues.

C. Engineer may require new mix design.

D. Engineer may require Hamburg Wheel-Track testing for up to 5 lots after cease production order at no additional expense to Owner.
   1. Engineer will take random sample at location behind paver for up to 5 lots after cease production order.
   2. Failure to meet mix design requirements will result in rejection of lot.

3.7 TOLERANCES

A. Smoothness: Maximum variation of 1/4 inch measured longitudinally, transversely, and at construction joints with 10-foot straight edge or string line. Correct depressions or humps exceeding tolerances.

B. Compacted Thickness:
   1. Owner accepts lot for thickness when:
      a. Average thickness of all sublots is not more than 1/2 inch greater, or 1/4 inch less than total thickness specified.
      b. No individual sublot shows deficient thickness of more than 3/8 inch.
   2. Thickness:
      a. Excess Thickness: Engineer may allow excess thickness to remain in place or may order excess thickness to be removed.
      b. Deficient Thickness: Place additional material where lots or sublots are deficient in thickness.

C. Variation from Indicated Elevation: Within 1/2 inch.

D. Elevation Difference between Top of Asphalt Pavement and Gutter: Maximum 1.0 inch. Remove and replace asphalt pavement, or remedy as indicated by Engineer at no cost to Owner.

3.8 FIELD QUALITY CONTROL

A. Section 017800 - Closeout Procedures: Requirements for testing, adjusting, and balancing.

B. Take samples and perform tests including asphalt paving thickness and mat density tests in accordance with NCDOT standards.

C. Asphalt Paving Mix Temperature: Measure temperature at time of placement.

3.9 PROTECTION

A. Section 017800 - Closeout Procedures: Requirements for protecting finished Work.

B. Do not allow traffic to cross saw cut edge of existing pavement unless temporary ramp is constructed.

C. Protect structures, and other objects from being spattered or marred by tack coat.

D. Do not allow construction vehicles, general traffic, or rollers to pass over uncompacted end or edge of freshly placed mix until mat temperature drops to point where damage or differential compaction will not occur.

E. Where necessary, protect pavement edges by placing planks of same thickness as pavement adjacent to longitudinal or transverse joints until surface course is completed.

F. Immediately after placement, protect paving from mechanical injury for 3 hours or until surface temperature is less than 140 degrees F.

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SECTION 32 13 13

CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aggregate subbase and base course.
2. Concrete paving for:

a. Concrete sidewalks.
b. Concrete stair steps.
c. Concrete integral curbs and gutters.
d. Concrete median barriers.
e. Concrete parking areas and roads.

1.2 REFERENCE STANDARDS

A. ASTM International:
1. ASTM A767/A767M - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
2. ASTM A775/A775M - S Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
3. ASTM A884/A884M - Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement.
4. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
5. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
6. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
7. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete.
8. ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete.
9. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
10. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
11. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
12. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
13. ASTM C979 - Standard Specification for Pigments for Integrally Colored Concrete.
14. ASTM C1017/C1017M - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
15. ASTM C1064/C1064M - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.

16. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

B. North Carolina Department of Transportation (NCDOT):
1. NCDOT Standard Specifications for Roads and Structures (NCDOT Specifications):

1.3 PRE-INSTALLATION MEETINGS

A. Conduct a meeting a minimum of one week prior to commencing work of this section.

1.4 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Product Data:

1. Submit data on concrete materials, joint filler, admixtures, and curing compounds.

C. Design Data:

1. Submit concrete mix design for each concrete strength. Submit separate mix designs when admixtures are required for the following:

a. Hot and cold weather concrete work.

2. Identify mix ingredients and proportions, including admixtures.

D. Source Quality Control Submittals: Indicate results of tests and inspections.

1.5 QUALITY ASSURANCE

A. Obtain cementitious materials from same source throughout.

B. Perform Work according to NCDOT and Municipal of standards.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products and listed on NCDOT's approved supplier list.

B. Installer: Company specializing in performing work of this section and listed on NCDOT's approved installer list.

1.7 AMBIENT CONDITIONS

A. Section 015000 - Temporary Facilities and Controls: Ambient conditions control facilities for product storage and installation.

B. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

PART 2 - PRODUCTS

2.1 AGGREGATE SUBBASE and BASE COURSE

A. Aggregate Subbase and Base Course: As specified in Section 321123.

2.2 CONCRETE PAVING

A. Form Materials:

1. Form Materials: As specified in Section 031000.
2. Joint Filler: ASTM D1751; Asphalt impregnated fiberboard or felt, 1/4 inch thick.

B. Reinforcement:

1. Reinforcing Steel and Wire Fabric: Type specified as indicated on the Plan Drawings.

C. Concrete Materials:

1. Concrete Materials: Provide according to NCDOT of standards.
2. Water: ASTM C94/C94M; potable,.
3. Air Entrainment: ASTM C260.
4. Chemical Admixture: ASTM C494/C494M. Use a quantity of chemical admixture within the range shown on the current list of approved admixtures issued by the Materials and Test Unit of NCDOT.

    a. Type A - Water Reducing.
    b. Type B - Retarding.
    c. Type C - Accelerating.
    d. Type D - Water Reducing and Retarding.
    e. Type E - Water Reducing and Accelerating.
    f. Type F - Water Reducing, High Range.
    g. Type G - Water Reducing, High Range and Retarding.

5. Fly Ash: In accordance with NCDOT standards.
6. Slag: In accordance with NCDOT standards.
7. Plasticizing: ASTM C1017/C1017M Type I, plasticizing or Type II, plasticizing and retarding.
8. Color Pigment: ASTM C979; mineral oxides, alkali and fade resistant.

a. Color: As directed by the Engineer and Owner..

2.3 FABRICATION

A. Fabricate reinforcing according to NCDOT standards.

B. Form standard hooks for 180-degree bends, 90-degree bend, and seismic hooks as indicated on Drawings.

2.4 MIXES

A. Concrete Mix:
1. Select proportions for normal weight concrete according to NCDOT standards.
2. Provide concrete compressive strength, slump, minimum cement content and air entrainment in accordance with NCDOT Standard Specifications for Roads and Structures, latest edition, Section 1000.

3. Limit the following cementitious materials to maximum percentage by mass of all cementitious materials:

a. Fly Ash: In accordance with NCDOT standards..
b. Blast Furnace Slag: In accordance with NCDOT standards..
c. Fly Ash and Blast Furnace Slag: In accordance with NCDOT standards..

4. Use accelerating admixtures in cold weather only when approved by the Engineer in writing. Use of admixtures will not relax cold weather placement requirements.
5. Use calcium chloride only when approved by the Engineer in writing.
6. Use set retarding admixtures during hot weather only when approved by the Engineer in writing.

2.5 FINISHES

A. Shop Finishing - Reinforcement:

1. Galvanized Finish for Steel Bars: ASTM A767/A767M, Class I, hot dip galvanized after fabrication.
2. Epoxy Coated Finish for Steel Bars: ASTM A775/A775M.

B. Epoxy Coated Finish for Steel Wire: ASTM A884/A884M; Class A, using ASTM A775/A775M.

2.6 ACCESSORIES

A. Curing Compounds: In accordance with NCDOT standards..

B. Liquid Surface Sealer: In accordance with NCDOT standards..

C. Surface Retarder: In accordance with NCDOT standards..

D. Joint Sealers: Specified in Section 079000.

2.7 SOURCE QUALITY CONTROL

A. Submit proposed mix design of each class of concrete to Engineer for review prior to commencement of Work.

B. Tests on cement, aggregates, and mixes shall be performed to ensure conformance with specified requirements.

C. Test samples according to ASTM C94/C94M

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 017800 - Closeout Procedures: Requirements for installation examination.

B. Verify compacted subbase, subgrade, granular fill, or stabilized soil is dry and ready to support paving and imposed loads.
   1. Proof roll subbase, subgrade, granular fill, or stabilized soil with 20-ton tandem axle dual wheel dump truck loaded to the legal limit with the tires inflated to 100 psi in minimum in two perpendicular passes to identify soft spots. Proof roll shall be done in the presence of the RPR or authorities having jurisdiction.
   2. Soft areas of the subbase, subgrade, granular fill, or stabilized soil that deflect more than 1 inch or show permanent deformations greater than 1 inch shall be removed and replaced with suitable materials or reworked to conform to the moisture content and compactions requirements in accordance with these specifications. Remove soft subbase, subgrade, granular fill, or stabilized soil and replace with compacted fill as specified in Section 312323.
   3.

C. Verify gradients and elevations of base are correct.

3.2 PREPARATION

A. Section 017800 - Closeout Procedures: Requirements for installation preparation.

B. Moisten substrate to minimize absorption of water from fresh concrete.

C. Coat surfaces of utility structure frames with oil to prevent bond with concrete paving.

D. Notify Engineer minimum 24 hours prior to commencement of concreting operations.

3.3 INSTALLATION

A. Subbase and Base Course:

1. Aggregate Subbase and Base Course: Install as specified in Section 321123.

B. Forms:

1. Place and secure forms and screeds to correct location, dimension, profile, and gradient.
2. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

C. Reinforcement:

1. Place reinforcing as indicated on Drawings.
2. Interrupt reinforcing at contraction and expansion joints.
3. Place dowels and reinforcing to achieve paving and curb alignment as detailed.
4. Provide doweled joints as indicated on the Drawings.
5. Repair damaged galvanizing to match shop finish.

D. Placing Concrete:

1. Coordinate installation of snow melting components.
2. Ensure reinforcing, inserts, embedded parts, and formed joints are not disturbed during concrete placement.
3. Place concrete continuously over the full width of the panel and between predetermined construction joints.
4. Place concrete to pattern indicated.

E. Joints

1. Saw cut contraction joints 3/16 inch wide at an optimum time after finishing. Cut 1/3 into depth of slab.
2. Seal joints as indicated on Drawings.

F. Exposed Aggregate:

1. Apply surface retarder where exposed aggregate finish is required.
2. Wash exposed aggregate surface with clean water and scrub with stiff bristle brush exposing aggregate to match plan requirements..

G. Finishing:

1. Area Paving: Wood float.
2. Sidewalk Paving: Light broom radius, and trowel joint edges.
3. Median Barrier: Light broom radius, and trowel joint edges.
4. Curbs and Gutters: Light broom.
5. Direction of Texturing: Transverse to paving direction.
6. Inclined Vehicular Ramps: Broomed perpendicular to slope.
7. Place curing compound on exposed concrete surfaces immediately after finishing.

H. Curing and Protection

1. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.
2. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
3. Cure concrete floor surfaces.

3.4 TOLERANCES

A. Maximum Variation of Surface Flatness: 1/4 inch

B. Maximum Variation From True Position: 1/4 inch.

3.5 FIELD QUALITY CONTROL

A. Section 017800 - Closeout Procedures: Requirements for testing, adjusting, and balancing.

B. Perform field inspection and testing according to ASTM C94/C94M and NCDOT of standards.

C. Inspect reinforcing placement for size, spacing, location, support.

D. Testing firm shall take cylinders and perform slump and air entrainment tests according to NCDOT standards.

E. Strength Test Samples:

1. Sampling Procedures: ASTM C172.
2. Cylinder Molding and Curing Procedures: ASTM C31/C31M, cylinder specimens, standard cured.
3. Sample concrete and make one set of five cylinders for every 75 cu yds or less of each class of concrete placed each day and for every 5,000 sf of surface area paving.

F. Field Testing:

1. Slump Test Method: ASTM C143/C143M.
2. Air Content Test Method: ASTM C173/C173M.
3. Temperature Test Method: ASTM C1064/C1064M.
4. Measure slump and temperature for each compressive strength concrete sample.
5. Measure air content in air entrained concrete for each compressive strength concrete sample.

G. Cylinder Compressive Strength Testing:

1. Test Method: ASTM C39/C39M.
2. Test Acceptance: according to NCDOT standards.
3. Test cylinders in accordance with NCDOT standards.
4. Retain one cylinder for 56 days for testing when requested by Engineer.
5. Dispose remaining cylinders when testing is not required.

H. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

3.6 PROTECTION

A. Section 017800 - Closeout Procedures: Requirements for protecting finished Work.

B. Immediately after placement, protect paving from premature drying, excessive hot or cold temperatures, and mechanical injury.

C. Do not permit pedestrian or vehicular traffic over paving until accepted by Engineer.

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fence framework, fabric, and accessories.
2. Excavation for post bases.
3. Concrete foundation for posts.
4. Manual gates and related hardware.
5. Privacy slats.

1.2 REFERENCES

A. ASTM International:

1. ASTM A121 - Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
2. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
3. ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
4. ASTM F567 - Standard Practice for Installation of Chain-Link Fence.
5. ASTM F900 - Standard Specification for Industrial and Commercial Swing Gates.
6. ASTM F934 - Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
7. ASTM F1043 - Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
8. ASTM F1083 - Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
9. ASTM F1184 - Standard Specification for Industrial and Commercial Horizontal Slide Gates.

B. Chain Link Fence Manufacturers Institute:

1. CLFMI - Product Manual.

1.3 SYSTEM DESCRIPTION

A. Fence Height: as indicated on Drawings.

B. Line Post Spacing: At intervals not exceeding 10 feet, unless otherwise indicated on the Drawings.

C. Fence Post and Rail Strength: Conform to ASTM F1043.

1.4 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Shop Drawings: Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.

C. Product Data: Submit data on fabric, posts, accessories, fittings and hardware.

1.5 CLOSEOUT SUBMITTALS

A. Section 017800 - Closeout Procedures: Closeout procedures.

B. Project Record Documents: Accurately record actual locations of property perimeter posts relative to property lines and easements.

C. Operation and Maintenance Data: Procedures for submittals.

1.6 QUALITY ASSURANCE

A. Supply material according to CLFMI - Product Manual.

B. Perform installation according to ASTM F567.

C. Perform Work according to jurisdictional standards.

1.7 QUALIFICATIONS

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

B. Installer: Company specializing in performing work of this section approved by manufacturer.

1.8 DELIVERY, STORAGE AND HANDLING

A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver fence fabric and accessories in packed cartons or firmly tied rolls.

C. Identify each package with manufacturer's name.

D. Store fence fabric and accessories in secure and dry place.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:

1. Allied Tube & Conduit; Atkore International.
2. Amico Corporation.
3. Master Halco.
4. Pacific Fence and Wire Company.
5. Substitutions: Section 016000 - Product Requirements.

2.2 MATERIALS AND COMPONENTS

A. Materials and Components: Conform to drawings, specifications, and CLFMI Product Manual.

B. Fabric Size: In accordance with plan drawings and CLFMI for the proposed fence usage. The contractor shall verify proposed fence usage prior to submitting bid and shop drawing.

C. Intermediate Posts: Type II round.

D. Terminal, Corner, Rail, Brace, and Gate Posts: Type II round.

2.3 MATERIALS

A. Framing (Steel): ASTM F1083 Schedule 40 galvanized steel pipe, welded construction, minimum yield strength of 25 ksi; coating conforming to ASTM F1043 Type A on pipe exterior and interior.

B. Fabric Wire (Steel): ASTM A392 Class 1 zinc coated steel wire.

C. Barbed Wire: ASTM A121 Coating Type Z, galvanized steel; 12 gage thick wire, 2 strands, 4 points at 3-inch on center, unless otherwise indicated.

D. Concrete: Normal Portland Cement, 3,000 psi strength at 28 days.

2.4 COMPONENTS

A. Line Posts: Diameter shall in be accordance with Drawings.

B. Corner and Terminal Posts: in accordance with Drawings.

C. Gate Posts: in accordance with Drawings.

D. Top and Brace Rail: 1.66-inch diameter, plain end, sleeve coupled.

E. Gate Frame: 1.66-inch diameter for welded, fittings and truss rod fabrication.

F. Fabric: 2-inch diamond mesh interwoven wire, 9 gage thick, top salvage knuckle end closed, bottom selvage knuckle end closed.

G. Tension Wire: 6 gage thick steel, single strand, marcelled, spiraled or crimped, aluminum-coated tension wire conforming to ASTM A824.

H. Tension Wire: ASTM A824, 6 gage, marcelled wire with Type II zinc-coated, Class 2.

I. Tie Wire: Aluminum alloy steel wire.

2.5 ACCESSORIES

A. Caps: Cast steel galvanized or Malleable iron galvanized; sized to post diameter, set screw retainer.

B. Fittings: Sleeves, bands, clips, rail ends, tension bars, fasteners and fittings; galvanized steel.

C. Extension Arms: Cast steel galvanized, to accommodate number of strands of barbed wire indicated on Drawing, single arm, sloped to 45 degrees.

D. Gate Hardware: Fork latch with gravity drop; two 180-degree gate hinges for each leaf, unless indicated otherwise on Drawings.

2.6 GATES

A. General:

1. Gate Types, Opening Widths and Directions of Operation: As indicated on Drawings.
2. Factory assembled gates.
3. Design gates for operation by one person.

B. Swing Gates:

1. Fabricate gates to permit 180-degree swing.
2. Gates Construction: ASTM F900 with welded corners. Use of corner fittings is not permitted.

C. Sliding Gates:

1. Framing and Posts: ASTM F1184, Class 2 for internal rollers.
2. Rollers for overhead and cantilever sliding gates: Bearing type. Furnish non-sealed bearings with grease fitting for periodic maintenance.
3. Secure rollers to post or frame without welding.

2.7 FINISHES

A. Components and Fabric: Vinyl coating, color as indicated on Drawings and according to ASTM F934 over galvanized coating.

B. Vinyl Components: color to match fabric as selected.

C. Hardware: Galvanized to ASTM A153/A153M, 2.0 oz/sq ft coating.

D. Accessories: Same finish as framing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install framework, fabric, accessories and gates according to ASTM F567. For tennis courts, install fencing and gates in accordance with ASTM F969.

B. Set corner, line, intermediate, terminal, and gate, posts plumb, in concrete footings with top of footing 6 inches below finish grade. Slope top of concrete for water runoff.

C. 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.

D. Install top rail through line post tops and splice with 6-inch-long rail sleeves.

E. Install center and bottom brace rail on corner gate leaves.

F. Place fabric on outside of posts and rails.

G. Do not stretch fabric until concrete foundation has cured 7 days.

H. Stretch fabric between terminal posts or at intervals of 100 feet maximum, whichever is less.

I. Position bottom of fabric 2 inches above finished grade.

J. Fasten fabric to top rail, line posts, braces, and bottom tension wire with tie wire at maximum 15 inches on centers.

K. Attach fabric to end, corner, and gate posts with tension bars and tension bar clips.

L. Install bottom tension wire and strap stretched taut between terminal posts.

M. Install support arms sloped outward and attach barbed wire; tension and secure.

N. Support gates from gate posts. Do not attach hinged side of gate from building wall.

O. Install gate with fabric and barbed wire overhang to match fence. Install three hinges on each gate leaf, latch, catches, drop bolt torsion spring retainer and locking clamp.

P. Provide concrete center drop to footing depth and drop rod retainers at center of double gate openings.

Q. Install posts with 6 inches maximum clear opening from end posts to buildings, fences and other structures.

R. Excavate holes for posts to diameter and spacing indicated on Drawings without disturbing underlying materials.

S. Center and align posts. Place concrete around posts and vibrate or tamp for consolidation. Verify vertical and top alignment of posts and make necessary corrections.

T. Extend concrete footings 1 inches above grade, and trowel, forming crown to shed water.

U. Allow footings to cure minimum 7 days before installing fabric and other materials attached to posts.

3.2 PRIVACY SLATS

A. Install slat inserts in pattern indicated on drawings woven through fence fabric.

B. Fasten slats according to manufacturer's instructions.

3.3 ERECTION TOLERANCES

A. Maximum Variation from Plumb: 1/4 inch.

B. Maximum Offset from Indicated Position: 1 inch.

C. Minimum distance from property line: 6 inches.

SECTION 32 92 19

SEEDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fertilizing.
2. Seeding.
3. Mulching.
4. Maintenance.

1.2 DEFINITIONS

A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass. Additionally, the definition of weeds includes vegetative species other than specified species to be established in given area.

1.3 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Product Data: Submit data for seed mix, fertilizer, mulch, and other accessories.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

A. Section 017800 - Closeout Procedures: Requirements for submittals.

1.5 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.

B. Perform Work according to these Plans and authorities having jurisdiction.

1.6 QUALIFICATIONS

A. Seed Supplier: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing work of this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 016000 - Product Requirements: Product storage and handling requirements.

B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.8 WARRANTY

A. Time Period: Guarantee that all lawns and grasses shall be in a healthy and flourishing condition of active growth for the warranty period as specified in the Contract Agreement with the Owner.

B. Appearance During Warranty:
   1. Lawns: Shall be free of dead or dying patches, and all areas shall show foliage of a normal density, size, and color. Complete lush cover with no brown sections or cracks showing.

C. Delays: All delays in completion of planting operations which extend the planting into more than one planting season shall extend the Warranty Period correspondingly.

D. Exceptions: Contractor shall not be held responsible for failures due to neglect by Owner, vandalism, etc., during Warranty Period. Report such conditions in writing.

E. Replacements: Replace, without cost to Owner, and as soon as weather conditions permit, all lawns and grasses not in a vigorous, thriving condition, as determined by Landscape Architect during and at the end of Warranty Period.

1.9 MAINTENANCE SERVICE

A. Section 017800 - Closeout Procedures: Requirements for maintenance service.

B. Maintain seeded areas immediately after placement until grass is well established and exhibits vigorous growing condition through the warranty period.

PART 2 - PRODUCTS

2.1 SEED MIXTURE

A. Suppliers:
   1. Ernst Seeds (www.ernstseed.com)
   2. Pennington Seed (www.pennington.com)
   3. Or approved equal Substitutions: Section 016000 - Product Requirements.

B. Furnish materials according to these Plan Drawings and authorities having jurisdiction.

2.2 SOIL MATERIALS

A. Topsoil: Fertile, friable topsoil, typical for locality, capable of sustaining vigorous plant growth; free of subsoil, clay or impurities, plants, weeds and roots; pH within acceptable range for local planting; organic matter content between 4-12 percent of total dry weight. Additional soil characteristics within normal ranges as provided by soil test report.

2.3 SOIL AMENDMENT MATERIALS

A. When soil tests indicate the need for soil amendment, apply soil conditioners or fertilizers to amend soil to specified conditions.
   1. Fertilizer: Containing 50 percent of elements derived from organic sources; of proportion necessary to eliminate deficiencies of topsoil, as indicated in analysis.

B. Water: Clean, fresh, and free of substances or matter capable of inhibiting vigorous growth of plants.

C. Herbicide: For pre-plant preparation, a broad-spectrum non-selective contact herbicide. For post-plant weed control, a granular or liquid-applied pre-emergent herbicide. Chemicals must be approved for use in the State of North Carolina and be applied by licensed applicators. The Owners' Representative must be notified at least 48 hours in advance of herbicide applications.

D. Pesticide: Pesticides may be used for specific pest infestations, but only in limited application. Broad- spectrum insecticides applied over large portions of landscape will not be allowed. Chemicals must be approved for use in the State of North Carolina and be applied by licensed applicators. The Owner and/or Owners' Representative must be notified at least 48 hours in advance of pesticide applications.

2.4 ACCESSORIES

A. Mulching Material: As indicated on the drawings and in accordance with authorities having jurisdiction.

B. Fertilizer: Commercial grade; recommended for grass; of proportion necessary to eliminate deficiencies of topsoil, as indicated in analysis or as indicated on the soil test report and in accordance with authorities having jurisdiction.

C. Lime: As indicated on the drawings and in accordance with authorities having jurisdiction.

D. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.

E. Erosion Fabric: As indicated on the drawings and in accordance with authorities having jurisdiction.

2.5 SOURCE QUALITY CONTROL

A. Provide recommendation for soil amendment application rates for specified seed mix as result of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify prepared soil base is ready to receive the Work of this section.

3.2 PREPARATION

A. Prepare subgrade in accordance with Section 312213.00 – Rough Grading.

B. Once subsoil is lightly but firmly re-compacted, spread existing stockpiled topsoil over areas to be seeded to a 2-inch depth minimum after natural settlement occurs.

C. Final Grading:
   1. Stones, Weeds, Debris: Verify that all areas to receive lawns (as indicated in Drawings) are clear of stones larger than 1 inch diameter, weeds, debris and other extraneous materials.
   2. Grades: Verify that grades are within 1 inch of the required finished grades. Verify that soil preparation and fertilization has been installed as required by soil testing. Report all variations in writing.

D. Soil Moisture:
   1. Excessive Moisture: Do not commence work of this section when soil moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in air or clods will not break readily.
   2. Inadequate Moisture: Apply water, as necessary, to bring soil to an optimum moisture content for planting.

E. Apply soil amendments after smooth raking of topsoil and at application rate recommended by soil analysis.

3.3 SEEDING

A. Apply seed at rate indicated on the Drawings, unless otherwise specified by manufacturer. Rake in lightly.

B. Do not seed areas in excess of that which can be mulched on same day.

C. Planting Season: The planting season shall be ideal for the type of planting specified on the Drawings.

D. Do not sow immediately following rain, when ground is too dry, or when winds are over 12 mph.

E. Immediately following seeding, apply mulch to thickness indicated on the Drawings. Maintain clear of shrubs and trees.

F. Apply water with fine spray immediately after each area has been mulched. Saturate to 4 inches of soil.

3.4 SEED PROTECTION

A. Cover seeded slopes where grade is 4 inches per foot or greater with erosion control fabric. Roll fabric onto slopes without stretching or pulling.

B. Lay fabric smoothly on surface, bury top end of each section in 6-inch-deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12 inches. Backfill trench and rake smooth, level with adjacent soil.

C. Secure outside edges and overlaps at 36-inch intervals with stakes.

D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.

E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.5 MAINTENANCE

A. Mow grass at intervals as required by manufacturer and/or Agreement with Owner.

B. Neatly trim edges and hand clip where necessary.

C. Water to prevent grass and soil from drying out.

D. Control growth of weeds with hand removal or use of organic, targeted herbicides.

E. Immediately reseed areas showing bare spots.

F. Repair washouts or gullies.

G. Protect seeded areas with warning signs during maintenance period.

SECTION 33 05 61

CONCRETE MANHOLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Modular precast concrete manholes and structures with tongue-and-groove joints and masonry transition to cover frame, covers, anchorage, and accessories.
2. Masonry manhole and structure sections with masonry transition to cover frame, covers, anchorage, and accessories.
3. Cast-in-place concrete manholes and structures with masonry transition to cover frame, covers, anchorage, and accessories.
4. Doghouse manhole connections to existing sanitary and/or storm sewer lines.
5. Bedding and cover materials.
6. Vertical adjustment of existing manholes and structures.

1.2 DEFINITIONS

A. Bedding: Specialized material placed under manhole prior to installation and subsequent backfill operations.

1.3 REFERENCE STANDARDS

A. American Association of State Highway Transportation Officials:
1. AASHTO M306 - Standard Specification for Drainage, Sewer, Utility, and Related Castings.

B. American Concrete Institute:

1. ACI 530/530.1 - Building Code Requirements and Specification for Masonry Structures.

C. ASTM International:

1. ASTM A48/A48M - Standard Specification for Gray Iron Castings.
2. ASTM C32 - Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale).
3. ASTM C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
4. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.
5. ASTM C877 - Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.

6. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.
7. ASTM C923 - Standard Specification for Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
8. ASTM C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
9. ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

1.4 COORDINATION

A. Coordinate Work of this Section with connection to municipal sewer utility service, with Owner and Engineer, and trenching.

1.5 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Product Data: Submit manufacturer information for manhole covers, component construction, features, configuration, and dimensions.

C. Shop Drawings:

1. Indicate structure locations and elevations.
2. Indicate sizes and elevations of piping, conduit, penetrations, and other appurtenances.

D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

E. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.

F. Source Quality-Control Submittals: Indicate results of shop tests and inspections.

G. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

H. Qualifications Statement:

1. Submit qualifications for manufacturer.

1.6 CLOSEOUT SUBMITTALS

A. Section 017800 - Closeout Procedures: Requirements for submittals.

B. Project Record Documents: Record actual locations of manholes and connections, and record rim and invert elevations.

1.7 QUALITY ASSURANCE

A. Perform Work according to standards of authorities having jurisdiction.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

C. Handling: Comply with precast concrete manufacturer instructions and ASTM C913 for unloading and moving precast manholes and drainage structures.

D. Storage:

1. Store materials according to manufacturer instructions.
2. Store precast concrete manholes and drainage structures to prevent damage to Owner's property or other public or private property.
3. Repair property damaged from materials storage.

E. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.10 AMBIENT CONDITIONS

A. Section 015000 - Temporary Facilities and Controls: Requirements for ambient condition control facilities for product storage and installation.

B. Cold Weather Requirements: Comply with ACI 530/530.1.

1.11 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

1.12 WARRANTY

A. Section 017800 - Closeout Procedures: Requirements for warranties.

B. Furnish five-year manufacturer's warranty for concrete manholes.

PART 2 - PRODUCTS

2.1 CONCRETE AND MASONRY MANHOLES

A. Manufacturers:

1. Stay-Right Precast.
2. Hanson Pipe & Precast.
3. Mack Industries
4. Oldcastle Infrastructure Inc.; CRH Americas.
5. Substitutions: As specified in Section 016000 - Product Requirements.

B. Precast Concrete Manholes:

1. General:
   a. All manholes shall be constructed to the sizes, shapes, and dimensions and at the locations shown on the plans.
   b. Tapered section and transition sections, where required, shall be of eccentric cone design, having the same wall thickness and reinforcement as the cylindrical ring sections.
   c. Eccentric cone sections shall have a height of between 2 feet and 4 feet.
   d. Flat slab tops shall be required for very shallow manholes where shown or specified. Flat slab tops shall only be utilized when/where approved for use by the Engineer.
   e. The quality of materials, the process of manufacture, and the finished manhole sections shall be subject to inspection and approval by the Engineer. The manhole sections shall be perpendicular to their longitudinal axis.

2. Materials:

   a. Reinforced Precast Concrete:
      1) Comply with ASTM C478.
      2) Compressive Strength: 4,000 psi minimum at 28 days complying with ACI 318, and ACI 350.
      3) Maximum permissible absorption: 6 percent.
      4) Cement: Comply with ASTM C150, Type II.
      5) Aggregates: Fine aggregate shall be sand, while coarse aggregate shall be crushed gravel, both in accordance with ASTM C33.
      6) Water: potable.
      7) Reinforcement:
         a) The manhole sections shall have reinforcement as required to provide resistance to the hydrostatic and passive earth pressures to which they

will be subjected, and to provide adequate resistance to temperature and shrinkage cracking.

b) Bases and risers shall be reinforced with a single cage of steel placed within the center third of the wall.

c) Welded wire fabric shall be in accordance with ASTM A185.

d) Steel reinforcing bars shall be grade 60 deformed steel in accordance with ASTM A615.

e) The tongue or the groove of the joint shall contain one (1) line of circumferential reinforcement equal in area to that in the barrel of the manhole riser.

f) The minimum cross-sectional area of steel per linear foot shall be 0.12 square inches. Precast manhole sections shall fit together readily.

8) Thickness:

a) Unless otherwise shown on the plans, manhole diameters, wall thicknesses and bottom thicknesses shall be in accordance with NCDOT Standards. Cone sections shall have a minimum wall thickness of 8 inches at their top.

9) Base:

a) Suitable openings for inlet and outlet pipes shall be cast into the base section for standard connections and into the riser section for drop connections. These openings shall be circular, accurately located and appropriately sized for each manhole.

b) All manhole and wet well bases shall be monolithically poured complete with a bottom

c) When indicated on the drawings, precast concrete base sections shall be provided with extended base sections or increased bottom thickness to provide ballast to prevent flotation. Extended bases, as required by the drawings, may be included in the monolithic pour of the base or integrally cast as approved by the Engineer.

10) Height:

a) The height or depth of each manhole will vary with the location, but unless otherwise indicated, it shall be constructed such that the top of the manhole matches that of the finished grade surrounding the manhole and the invert is constructed at elevation shown on the plans.

b) As directed by the Engineer (or as otherwise indicated on the plans) the top elevations of some manholes maybe elevated above the finished grade of the surrounding area in wooded or other natural (unmaintained) areas.

c) In all cases, the number of manhole sections (joints) necessary to construct the required height shall be minimized.

11)

b. Gaskets: Comply with ASTM C443..

3. Joints:

a. Comply with ASTM C913.

b. Maximum Leakage: 0.025 gal. per hour per foot of joint at 3 feet of head.

C. Clay Brick Units:

1. Comply with ASTM C32.
2. Grade: MS.
3. Configuration: Solid.

D. Mortar and Grout:

1. Mortar: Comply with ASTM C270, Type M.

2. Grout: Non-shrink, comply with CRD-C 621 or ASTM C1107.

2.2 FRAMES AND COVERS

A. Manufacturers:

1. U.S. Foundry

2. EJ.
3. Neenah Foundry Company.
4. Substitutions: As specified in Section 016000 - Product Requirements.

B. Description:

1. Material:

a. Cast iron: Comply with ASTM A48.
b. Comply with AASHTO M306 and HS20 if installed within roadways.
c. Comply with NCDOT 840.54 if installed within state-maintained roadways.
d. The manufacturer shall furnish certified tensile test results performed by an independent testing laboratory, if requested by the ENGINEER.
e. All castings shall be true to manufacturer's approved submittal drawings. Actual dimensions of all castings shall have a tolerance of +/- 1/16”, and an additional 1/16-inch per foot of dimension. All casting components of the same part number shall be interchangeable.
f. All castings shall be free from blowholes, shrinkages or other surface imperfections.

2. Frame:
a. Standard casting shall be designed for heavy duty use and 190 pounds.
b. The minimum opening within the interior of the frame shall be 22-inches.
c. Height of the manhole frame shall be 7-1/2 inches.
d. The frame shall have a 4-inch minimum width flange
e. The frame shall have four (4) 1-inch diameter holes and shall be anchored to the precast concrete cone with stainless steel anchors and sealed with Butyl mastic rope.

3. Lid:
a. Standard casting shall be designed for removable and heavy duty use and shall be 125 pounds.
b. Lid shall be 23.5-inches in diameter

c. Lid shall include an indented top design with lettering cast into the cover, including the name of the manufacturer, the part number, country of origin, and an appropriate description such as one of the following:
   1) RECLAIMED WATER
   2) SANITARY SEWER
   3) STORM SEWER
   4) WATER
   5) OTHER APPROPRIATE WORDING
d. Lids shall have two non-penetrating pick holes or pick slots.
e. Security: as indicated on Drawings.

4. All manhole rings and covers shall be furnished with machined seating surfaces. Prior to shipping, the manufacturer shall fit up all casting components to ensure that all castings furnished are of proper fit and free from rattle.
5. Special waterproof manhole frame and covers shall be installed only at those locations indicated on the contract drawings.
   a. Manhole frames and covers shall be made watertight by installing a rubber O-ring gasket seal or a side seal gasket and installing either four countersunk stainless-steel hex head bolts with rubber gaskets or use a cam-loc style ring and cover.
   b. Watertight rings and lids shall be U.S. Foundry 669-KL-BWTL with a 125-pound cover, or approved equal.

2.3 RISER RINGS

A. Manufacturers:

1. EJ.
2. Neenah Foundry Company.
3. Substitutions: As specified in Section 016000 - Product Requirements.

B. Riser Rings:
   1. Description:
      a. Precast reinforced concrete grade rings or brick shall be used to adjust ring and covers to finished grade.
   2. Precast Riser Rings:
      a. Comply with ASTM C478.
      b. No more than 12 vertical inches of grade rings or brick will be allowed per manhole.
      c. Grade rings shall be no less than 6 inches and no more than 9 inches in height with a diameter matching that of the frame and cover.
      d. Rubber Seal Wraps:
         1) Wraps and Band Widths: Comply with ASTM C877, Type III.
         2) Cone/Riser Ring Joint: Minimum 3-inch overlap.
         3) Frame/Riser Ring Joint: 2-inch overlap.
         4) Additional Bands: Overlap upper band by 2 inches.

C. Manhole Openings
   1. Precast utility structures shall be furnished with water stops, sleeves and openings as noted on the Drawings.
   2. Manhole openings shown on the drawings shall be cast in place unless otherwise noted.

3. All penetrations needed though not shown on drawings shall be mechanically cored and installed with approved flexible watertight connector.

D. Flexible Pipe Boots for Manhole Pipe Entrances
   1. Manufacturers:
      a. Connector shall be the PSX Direct Drive assembly by Press-Seal Gasket Corporation, the Kor-N-Seal I 106-406 Series by Trelleborg Pipe Seals, or approved equal.
      b. Furnish materials according to ASTM C923.
   2. Description:
      a. Material: EPDM or material approved by ENGINEER.
      b. Comply with ASTM C923.
      c. Attachment: stainless-steel clamp and hardware.
      d. Deflection: permit at least an 7° deflection from the centerline of the opening in any direction while maintaining a watertight connection.
      e. Seal: Joints shall be watertight under 30 feet of water in straight alignment for 10 minutes.
      f. Seal: Joints shall be watertight under 23 feet of water at 7° deflection for 10 minutes.

2.4 MATERIALS

A. Cover and Bedding:

   1. Bedding: Fill Type: as specified on Drawings.
   2. Cover: Fill Type as specified on Drawings.

2.5 ACCESSORIES

A. Steps:
   1. Steps shall be a copolymer polypropylene plastic reinforced grade 60 bar and have serrated tread and tall end lugs.
   2. Step pull out strength shall be a minimum of 2,000 pounds when tested according to ASTM C497. Each step shall also have a vertical load resistance of 400 pounds.
   3. Steps shall be required in all structures with a depth greater than four (4) feet. Steps shall be vertically aligned and uniformly spaced for the entire depth of the structure. Steps shall be located in the structures along the vertical face of the eccentric cone and so as to land upon a bench.
   4. Secure steps to the wall with a compression fit in tapered holes. Steps shall not be vibrated or driven into freshly cast concrete. Steps shall not be grouted in place.
   5. Diameter: 1/2 inch.
   6. Width: Minimum 12 inches.
   7. Spacing: Between 12 and 16 inches o.c. vertically, set into structure wall.
   8. Protrusion: Between 5 and 7 inches.

B. Concrete Section Joint Sealant
   1. Manufacturers:

a. Compound shall be NPC Bidco C-56 Butyl Joint Sealant, Henry Company Butyl-Nek Preformed Plastic Joint Sealant (BN109), Conseal CS-102, or approved equal.

2. Description:
   a. Comply with ASTM C990 and Federal Specification SS-S210A, AASHTO M-198, Type B - Butyl Rubber
   b. Joints shall be sealed by two (2) butyl rubber seals. Each seal shall be as described below:
      1) Butyl Seals shall consist of a plastic or paper-backed butyl rubber rope no less than 1-inch cross section.
      2) When manholes are larger than 4 feet diameter or have a larger than normal space between the joints, the length and or diameter of the rope shall be increased as required to achieve a seal.
      3) Butyl rubber shall be applied to clean, dry surfaces only.
      4) Use of 2 independent wraps of Butyl Rubber placed side-by-side (not stacked) qualifies for the requirement of two seals.
3. Internal O-Ring Gaskets and Internal Rubber Gaskets shall not be used.

C. Watertight Exterior Joint Seal
1. Manufacturer:
   a. Asphalt sealant shall be Carboline, Bitumastic 300m; Tnemec, Tneme-Tar; or approved equal.
2. Description:
   a. Watertight exterior joint seal shall be installed after joining manhole sections as specified herein.
   b. Butyl joint wrap shall be minimum width 12-inches and comply with ASTM C877.

D. Fasteners: Stainless steel; ASTM F593.

E. Concrete: As specified.

F. Manhole Vents:
1. Where designated on the contract drawings, a 4-inch diameter vent pipe shall be installed as an integral part of the manhole.
2. Material: Schedule 40 steel
3. Coating: a 3/32 inch coal tar interior lining and have an exterior finish consisting of two (2) coats of epoxy paint as approved by the ENGINEER.
4. The vent pipe is to be tapped into the upper most section of the manhole, anchored in concrete and extended vertically to the elevation shown on the drawings.
5. The pipe shall have a reverse bend and screen to prohibit rain and foreign materials from entering pipe.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 017800 - Closeout Procedures: Requirements for installation examination.

B. Verify that items provided by other Sections of Work are properly sized and located.

C. Verify that excavation base is ready to receive Work and excavations and that dimensions and elevations are as indicated on Drawings.

3.2 PREPARATION

A. Section 017800 - Closeout Procedures: Requirements for installation preparation.

B. Mark each precast structure by indentation or waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers as indicated on Drawings to indicate its intended use.

C. Coordinate placement of inlet and outlet pipe or duct sleeves as required by other Sections.

D. Do not install manholes and structures where Site conditions induce loads exceeding structural capacity of manholes or structures.

E. Inspect precast concrete manholes and structures immediately prior to placement in excavation to verify that they are internally clean and free from damage; remove and replace damaged units.

3.3 INSTALLATION

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface structures or utilities in immediate or adjacent areas.

B. Correct over-excavation with coarse aggregate.

C. Remove large stones or other hard matter impeding consistent backfilling or compaction.

D. Protect manhole from damage or displacement while backfilling operation is in progress.

E. Excavating:

1. As specified in Section 312316 - Excavation and in indicated locations and depths.
2. Provide clearance around sidewalls of manhole or structure for construction operations and, granular backfill.
3. If ground water is encountered, prevent accumulation of water in excavations; place manhole or structure in dry trench.
4. Where possibility exists of watertight manhole or structure becoming buoyant in flooded excavation, anchor manhole or structure to avoid flotation as approved by Engineer.

F. Base and Alignment:
1. The manhole foundation shall be prepared so as to provide a firm, level area on which to place the precast concrete manhole base section.
2. Install manholes supported at proper grade and alignment on 8-inch of No. 57 stone, or as indicated on Drawings.

3. When poor foundation soil is encountered or excess groundwater exists, the foundation shall be excavated 12 inches or greater below the final subgrade elevation, as determined by the soils engineer and backfilled with washed stone to provide a proper foundation.
4. Form and place manhole or structure cylinders plumb and level, to correct dimensions and elevations.

G. Backfilling: As specified.

H. Coating: Interior coating not required unless otherwise specified.

I. Precast Concrete Manholes:

1. Lift precast components at lifting points designated by manufacturer.
2. When lowering manholes and structures into excavations and joining pipe to units, take precautions to ensure that interior of pipeline and structure remains clean.
3. Assembly:

    a. Assemble multisection manholes and structures by lowering each section into excavation.
    b. Install rubber gasket joints between precast sections according to manufacturer recommendations.
    c. Lower, set level, and firmly position base section before placing additional sections.

4. Remove foreign materials from joint surfaces and verify that sealing materials are placed properly.
5. Maintain alignment between sections by using guide devices affixed to lower section.
6. Joint sealing materials may be installed on Site or at manufacturer's plant.
7. Unroll the butyl sealant directly against the base of the spigot. Leave protective wrapper attached until sealant is entirely unrolled against spigot. Do not stretch. Overlap from side to side - not top to bottom.
8. Verify that installed manholes and structures meet required alignment and grade.
9. Remove knockouts or cut structure to receive piping without creating openings larger than required to receive pipe; fill annular spaces with mortar.
10. Cut pipe flush with interior of structure.
11. Inverts and Benches:
    a. Manhole inverts and benches shall be constructed of brick and cement grout or precast concrete in accordance with the standard details shown on the drawings.
    b. Inverts shall have a "U" shaped cross section of the same diameter as the invert of the sewers which they connect. "U" shaped inverts shall be constructed to a minimum depth of 6 inches for 8-inch sewers and to full pipe diameter depth of the outlet sewer main for larger mains.
    c. The manhole invert shall be carefully formed to the required size and grade by gradual and even changes in sections.
    d. Changes in direction of flow through the manhole, whether horizontal or vertical, shall be made with true tangent curve(s) with as large a radius as the size of the manhole will permit. Provide a 1/2-inch radius at the intersection of 2 or more channels.
    e. Manhole benches shall be constructed with a slope of 1 inch per foot (8 percent) sloped toward the invert channel. Finish benches shall provide a uniform slope

from the high point at the manhole wall to the low point at invert channel. Provide a radius (1/8 inch to 1 inch range is acceptable) at the edge of the bench and channel.

f. When the invert and bench are not constructed by the precast manufacturer, the Contractor shall construct the invert and bench using 3,000 psi concrete or non-shrink grout. Non-shrink grout may be plastered over layered brick and mortar in lieu of solid non-shrink grout invert.

g. Gradual smooth sided depressions and high spots may be allowed so long as diameter of invert channel ranges from 1/4 inch less than, or 1/2 inch more than the nominal pipe diameter are maintained. Voids, chips, or fractures over 1/8 inch in diameter or depth shall be filled with a non-shrink grout and finished to a texture reasonably consistent with the bench surface. All work from collar down shall have a steel trowel finish.

12. Pipe Openings:

a. Pipe openings shall provide clearance for pipe projecting a minimum of 2 inches inside the manhole. The crown of smaller diameter pipes shall be no lower than the crown of the outlet pipe. Grout pipe penetrations, including pipe crown, to provide a smooth, uniform finish using non-shrink grout.

b. Pipe openings shall be exactly aligned to that of the pipe entering and leaving the manhole. The gravity sanitary sewer pipe lines shall be placed in the manhole openings, properly aligned, and set to grade. Sanitary sewer shall be connected to the manholes using flexible manhole sleeves as described herein.

c. For large diameter pipe where a flexible rubber sleeve is not available, the pipe line shall be sealed into the manhole using an expanding type or non-shrink type grout.

J. Doghouse Manholes and Structures:

1. Stake out location and burial depth of existing sewer line in area of proposed manhole or structure.
2. Carefully excavate around existing sewer line to adequate depth for foundation slab installation.
3. Protect existing pipe from damage.
4. Cut out soft spots and replace with granular fill compacted to 95 percent maximum density.
5. Bear firmly and fully on compacted crushed stone bedding or support system as indicated on Drawings.
6. Install manhole or structure around existing pipe according to applicable Paragraphs in this Section.
7. Grout pipe entrances as specified.
8. Coordinate connections to existing pipe with Owner and Engineer.
9. Block upstream flow at existing manhole or structure with expandable plug.
10. Use hydraulic saw to cut existing pipe at manhole or structure entrance and exit and along pipe length at a point halfway up OD on each side of pipe.
11. Bottom half of pipe is to remain as manhole flow channel.
12. Saw cut to smooth finish with top half of pipe flush with interior of manhole or structure.
13. Grout base of manhole or structure to achieve slope to manhole or structure and trowel smooth.

K. Sanitary Manhole Drop Connections:

1. Standard drop manholes will be constructed only at those locations shown on the drawings or as approved by the Engineer.
2. The design of the drop connection shall be in accordance with the standard detail drawing.
3. The cost of the extra pipe, labor, etc. required to construct a drop manhole will be included in the unit price for the drop manhole at the depths indicated.

L. Castings:
1. Set the manhole frames to the required elevation using no more than 12 inches of precast concrete grade rings, or bricks sealing all joints between cone, adjusting rings, and manhole frame.
2. When grade rings or bricks are used, grout with non-shrink grout.
3. Install radially laid concrete brick with 1/4-inch-thick, vertical joints at inside perimeter.
4. Lay concrete brick in full bed of mortar and completely fill joints.
5. If more than one course of concrete brick is required, stagger vertical joints.
6. Manhole frames which are placed above final grade will have frames attached to manhole cone section by means of 5/8-inch diameter stainless steel anchors and washers. One anchor bolt shall be provided per hole.
7. Seal pipe penetrations, including pipe crown, to provide a smooth, uniform finish using non-shrink grout.
8. When flat slab tops are utilized, frames shall be cast into the top for access into manholes.

3.4 FIELD QUALITY CONTROL

A. Section 017800 - Closeout Procedures: Requirements for testing, adjusting, and balancing.

B. Testing:

1. Cast-in-Place Concrete: As specified.
2. Concrete Manhole Sections: As specified.

C. After the placement of manhole frame and vacuum testing, perform the final finishing to the manhole interior by filling all chips or fractures greater than 1/2 inch in length, width or depth (1/8-inch-deep in inverts) with non-shrink grout. Grout the interior joints between the precast concrete sections with non-shrink grout. Sharp edges or rough finishes shall be removed providing a smooth surface throughout the manhole. Clean the interior of the manhole, removing all dirt, spills, or other foreign matter.

D. Equipment Acceptance: Adjust, repair, modify, or replace components failing to perform as specified and rerun tests.

3.5 ADJUSTING

A. Section 017800 - Closeout Procedures: Requirements for starting and adjusting.

B. Vertical Adjustment of Existing Manholes and Structures:
1. If required, adjust top elevation of existing manholes and structures to finished grades as indicated on Drawings.

2. Frames, Grates, and Covers:

    a. Remove frames, grates, and covers cleaned of mortar fragments.
    b. Reset to required elevation according to requirements specified for installation of castings.
3. After the manhole has been set in its final position, set the manhole frames to the required elevation using no more than 12 inches of precast concrete grade rings, or bricks sealing all joints between cone, adjusting rings, and manhole frame. When grade rings or bricks are used, grout with non-shrink grout.
4. Where manholes are constructed in paved areas, the top surface of the frame and cover shall be tilted to conform to the exact slope, crown and grade of the existing surrounding pavement.
5. Manholes installed outside roadway areas, but in other landscaped or maintained areas shall be set flush with the surround grade, unless otherwise indicated.
6. Manholes installed in areas not regularly maintained shall be set approximately 24-inches above the surrounding grade.

SECTION 33 42 00

STORMWATER CONVEYANCE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Stormwater drainage piping.
2. Manholes.
3. Catch basins.
4. Cleanouts.
5. Concrete encasement and cradles.
6. Bedding and cover materials.

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials:
1. AASHTO M36 – Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains
2. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Pipe.
3. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.
4. AASHTO M294 - Standard Specification for Corrugated Polyethylene Pipe, 12- to 60-in. Diameter.

B. ASTM International:
1. ASTM A746 - Standard Specification for Ductile Iron Gravity Sewer Pipe.
2. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
3. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
4. ASTM C990 – Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
5. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

1.3 COORDINATION

A. Coordinate Work of this Section with termination of storm sewer connection outside building, trenching, and connection to, municipal sewer utility service.

1.4 SUBMITTALS

A. Section 013400 - Submittals: Requirements for submittals.

B. Product Data: Submit manufacturer information describing pipe, pipe accessories, and structures.

C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

D. Manufacturer Instructions: Submit special procedures required to install specified products.

E. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

1.5 CLOSEOUT SUBMITTALS

A. Section 017800 - Closeout Procedures: Requirements for submittals.

B. Project Record Documents: Record actual locations of pipe runs, connections, catch basins, cleanouts, and other storm structures. Record rim, invert out and invert in of structures.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

A. Perform Work according to standards of authorities having jurisdiction.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience. If work is within the DOT right-of-way, then the manufacturer must be on the DOT approved vendors list.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

C. Store materials according to manufacturer instructions.

D. Protection:
   1. Provide protection according to manufacturer instructions.

1.9 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 STORM DRAINAGE PIPING

A. Ductile-Iron Piping:

1. Pipe:

a. Comply with ASTM A746, Class 50, unless indicated otherwise.
b. Type: As indicated on Drawings.
c. Diameter: As indicated on Drawings.
d. Ends: Bell and spigot.

2. Fittings: Ductile iron.
3. Joints:

a. Comply with ASTM A746.
b. Joint Devices: Rubber gasket.

B. Reinforced Concrete Piping:

1. Pipe:

a. Comply with ASTM C76, Class III, unless indicated otherwise.
b. Diameter: As indicated on Drawings.
c. End Connections: Bell and spigot.

2. Fittings: Reinforced concrete.
3. Joints:

a. Comply with ASTM C990 for joints using Preformed Flexible Joint Sealants.

b. Comply with ASTM C443 for joints using Rubber Gaskets.
c. Gaskets: Rubber, compression.

C. Corrugated PE Piping:

1. Pipe:

a. Comply with AASHTO M252 and M294, as applicable.
b. Type: Smooth Interior as indicated on Drawings.

c. Diameter: As indicated on Drawings.

2. Fittings: PE.
3. Joints: Comply with AASHTO M252, and AASHTO M294 as applicable.

D. Corrugated Steel Piping:

1. Pipe and Fittings:

a. Comply with AASHTO M36.
b. Nominal Diameter: As indicated on the Drawings.
c. Coating: Inside and outside, as indicated on Drawings.

2. Fittings: Corrugated steel.
3. Coupling Bands:

a. Material: Galvanized steel.
b. Minimum Size: 0.052 inch thick by 10 inches wide.
c. Connection: Two neoprene O-ring gaskets and two galvanized-steel bolts.

2.2 MANHOLES

A. As specified in Section 330561 – Concrete Manholes.

2.3 CATCH BASINS, DROP INLETS, JUNCTION BOXES, YARD INLETS

A. Shaft and Top Section:

1. Furnish materials according to Drawings and authorities having jurisdiction.

B. Lids and Frames:
1. Furnish materials according to Drawings and authorities having jurisdiction.

2.4 CONCRETE ENCASEMENT AND CRADLES

A. Concrete:

1. Description: concrete, as specified in Section 033000 - Cast-in-Place Concrete.
2. Compressive Strength: 3,000 psi at 28 days, unless otherwise indicated, concrete, rough troweled finish.

2.5 MATERIALS

A. Bedding and Cover: As indicated on Drawings, Specifications and in accordance with authorities having jurisdiction.

2.6 ACCESSORIES

A. Geotextile Filter Fabric:

1. Comply with AASHTO M288 for subsurface drainage.
2. Type: Class and type as indicated on Drawings.

B. Underground Pipe Markers: In accordance with authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 017800 - Closeout Procedures: Requirements for installation examination.

B. Verify that excavations, dimensions, and elevations are as indicated on Drawings.

3.2 PREPARATION

A. Section 017800 - Closeout Procedures: Requirements for installation preparation.

B. Correct over-excavation with bedding material as indicated on Drawings.

C. Remove large stones and other hard matter that could damage piping or impede consistent backfilling or compaction.

3.3 INSTALLATION

A. Excavation and Bedding:

1. Excavate trench to depth indicated on Drawings below pipe invert, and as specified in Section 312316.13 - Trenching.
2. Hand trim excavation for accurate placement of piping to indicated elevations.
3. Place bedding material at trench bottom.
4. Level materials in continuous layers as specified in Section 312316.13 - Trenching.
5. Maintain optimum moisture content of bedding material to attain required compaction density.
6. Place geotextile fabric over compacted bedding, as indicated on Drawings.

B. Piping:

1. Pipe, Fittings, and Accessories: Comply with ASTM D2321.
2. Seal joints watertight.
3. Place pipe on bedding as indicated on Drawings and in accordance with authorities having jurisdiction.
4. Cradle bottom of pipe diameter to avoid point load as indicated on Drawings.

5. Backfilling and Compaction:

    a. As indicated on Drawings, as specified in Section 312323 - Fill and in accordance with authorities having jurisdiction.
    b. Do not displace or damage pipe while compacting.

6. Manholes: As specified in Section 330561 - Concrete Manholes.
7. Pipe Markers: In accordance with authorities having jurisdiction.
8. Install Site storm drainage system piping to within 5’ feet of building.
9. Installation Standards: Install Work according to authorities having jurisdiction standards.

C. Catch Basins and Cleanouts:
    1. Installation Standards: Install Work according to the authority having jurisdiction.

3.4 TOLERANCES

A. Maximum Variation from Indicated Pipe Slope: 1/8 inch in 10 feet.

3.5 FIELD QUALITY CONTROL

A. Section 017800 - Closeout Procedures: Requirements for testing, adjusting, and balancing.

B. Request inspection by Engineer prior to and immediately after placing aggregate cover over pipe.

C. Testing:
    1. Compaction Test:

        a. Comply with recommendations of Geotechnical Engineer.
        b. Testing Frequency: As required by Geotechnical Engineer and authorities having jurisdiction.

    2. Manholes: As specified in Section 330561 - Concrete Manholes.
    3. Piping: Inspect pipe for rips, tears, joint separations, soil migration, cracks, localized buckling, settlement, alignment, and deflection.

    4. If tests indicate that Work does not meet specified requirements, remove Work, replace, and retest.

3.6 PROTECTION

A. Section 017800 - Closeout Procedures: Requirements for protecting finished Work.

B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

SECTION 34 71 13

PLASTIC BOLLARD COVERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Plastic bollard covers.
2. Accessories.

B. Related Requirements:

1. Section 05 50 00 Metal Fabrications

1.02 SUBMITTALS

A. Comply with Section 01 34 00 – Submittals.

B. Product Data: Provide for each type of bollard cover and accessory specified.

C. Color Samples: Submit manufacturer's standard color chart for selection.

1.03 QUALITY ASSURANCE

A. Comply with Section 01 60 00 – Product Requirements.

1.04 DELIVERY, STORAGE AND HANDLING

A. Comply with Section 01 60 00 – Product Requirements.

B. Protect bollards and accessories during delivery, storage, and handling.

1.05 WARRANTY

A. Provide manufacturer's standard warranty against defects in materials and workmanship.

1. Warranty Period: One year from date of project Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Design Standard: Encore Commercial Products, Inc. 37525 Interchange Dr. Farmington Hills, MI 48335 1-866- 737⁻8900; 248-354-4090; Fax: 248-354-4095; website: www.postguard.com.

B. Other manufacturer's products that meet all technical and performance characteristics, and other requirements of the contract documents.

C. Substitutions: Comply with provisions of Section 01 60 00 – Product Requirements for substitution procedures.

2.02 ACCESSORIES:

A. Self-adhesive foam strips.

B. Self-adhesive neoprene tape.

C. Reflective Tape: 2 strips of reflective sheeting tape, recessed on bollard.

2.03 PLASTIC BOLLARD COVERS

A. Materials:

1. High Density Polyethylene (HDPE).
    a. Ultraviolet protection additive.
    b. Abrasion Resistant.
    c. Environmental Stress Cracks Resistant.
2. Low-density thermoplastic polyethylene (LDPE).

B. Plastic Bollard Cover:

1. Height: As needed to completely cover steel bollards.
2. Base Diameter: 7 inches (17.78 cm).
3. Material: High Density Polyethylene (HDPE).
4. Color: Safety Yellow.
5. Tape Color: White.
6. Installation: Self-adhesive foam strips.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine metal bollards and other substrates for compliance with manufacturer's requirements for placement and location of embedded items, condition of substrate, and other conditions affecting installation of bollards.

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

3.02 INSTALLATION

A. General: Comply with manufacturer’s installation instructions and setting drawings.

B. Do not install damaged, cracked, chipped, deformed or marred bollards. Field touch-up minor imperfections in accordance with manufacturer’s instructions. Replace bollards that cannot be field repaired.

C. Plastic Bollard Covers: Install over foam strips in pattern indicated in manufacturer's instructions. Center two foam strips over bollard. Slide the cover over the bollard and allow foam to expand for a snug fit.

3.03 CLEANING & PROTECTION

A. Protect bollard covers against damage.

B. Immediately prior to Substantial Completion, clean bollards in accordance with manufacturer’s instructions to remove dust, dirt, adhesives, and other foreign materials.

C. Touch up damaged finishes according to manufacturer’s instructions.

3.04 CLOSEOUT ACTIVITIES

A. Provide executed warranty.

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