# **VOLUME 2**

## CAESAR RODNEY SCHOOL DISTRICT

SPECIFICATIONS FOR

Caesar Rodney High School Additions and Renovations

> In Camden-Wyoming, Delaware

> > PREPARED BY

StudioJAED Architects & Engineers

**ISSUED FOR:** 

**BID DOCUMENTS** 

June 15, 2017

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### **VOLUME I**

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#### SECTION 21 05 00 COMMON WORK RESULTS FOR FIRE SUPPRESSION

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

A. Pipe, fittings, valves, and connections for sprinkler, standpipe and fire hose, and combination sprinkler and standpipe systems.

#### 1.02 RELATED REQUIREMENTS

- A. Section 09 90 00 Painting and Coating: Preparation and painting of fire protection piping systems.
- B. Section 21 05 53 Identification for Fire Supp. Piping and Equipment: Piping identification.
- C. Section 22 05 53 Identification for Plumbing Piping and Equipment: Piping identification.
- D. Section 21 13 00 Fire-Suppression Sprinkler Systems: Sprinkler systems design.
- E. Section 21 12 00 Fire-Suppression Standpipes: Standpipe design.

#### 1.03 REFERENCE STANDARDS

- A. ASME BPVC-IX Boiler and Pressure Vessel Code, Section IX Welding, Brazing, and Fusing Qualifications.
- B. ASME B16.1 Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- C. ASME B16.3 Malleable Iron Threaded Fittings: Classes 150 and 300.
- D. ASME B16.4 Gray Iron Threaded Fittings: Classes 125 and 250.
- E. ASME B16.5 Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard.
- F. ASME B16.9 Factory-Made Wrought Buttwelding Fittings.
- G. ASME B16.11 Forged Fittings, Socket-welding and Threaded.
- H. ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings.
- I. ASME B16.22 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- J. ASME B16.25 Buttwelding Ends.
- K. ASME B36.10M Welded and Seamless Wrought Steel Pipe.
- L. ASTM A47/A47M Standard Specification for Ferritic Malleable Iron Castings.
- M. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- N. ASTM A135/A135M Standard Specification for Electric-Resistance-Welded Steel Pipe.
- O. ASTM A234/A234M Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- P. ASTM A795/A795M Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use.
- Q. ASTM B32 Standard Specification for Solder Metal.
- R. ASTM B75/B75M Standard Specification for Seamless Copper Tube.
- S. ASTM B75M Standard Specification for Seamless Copper Tube (Metric).
- T. ASTM B88 Standard Specification for Seamless Copper Water Tube.
- U. ASTM B88M Standard Specification for Seamless Copper Water Tube (Metric).
- V. AWS A5.8M/A5.8 Specification for Filler Metals for Brazing and Braze Welding.

- W. AWS D1.1/D1.1M Structural Welding Code Steel.
- X. AWWA C105/A21.5 Polyethylene Encasement for Ductile-Iron Pipe Systems.
- Y. AWWA C110/A21.10 Ductile-Iron and Gray-Iron Fittings.
- Z. AWWA C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- AA. AWWA C151/A21.51 Ductile-Iron Pipe, Centrifugally Cast.
- AB. NFPA 13 Standard for the Installation of Sprinkler Systems.
- AC. NFPA 14 Standard for the Installation of Standpipe and Hose Systems.
- AD. NFPA 24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances; National Fire Protection Association; 1995.
- AE. UL (DIR) Online Certifications Directory.
- AF. UL 262 Gate Valves for Fire-Protection Service; Underwriters Laboratories Inc..
- AG. UL 312 Check Valves for Fire-Protection Service; Underwriters Laboratories Inc..

#### 1.04 SUBMITTALS

- A. Product Data: Provide manufacturers catalogue information. Indicate valve data and ratings.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- C. Project Record Documents: Record actual locations of components and tag numbering.
- D. Operation and Maintenance Data: Include installation instructions and spare parts lists.

#### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years experience. approved by manufacturer.
- C. Conform to UL requirements.
- D. Valves: Bear UL label or marking. Provide manufacturer's name and pressure rating marked on valve body.
- E. Products Requiring Electrical Connection: Listed and classified as suitable for the purpose specified and indicated.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store valves in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

#### 1.07 EXTRA MATERIALS

A. Provide two valve stem packings for each size and type of valve installed.

#### PART 2 PRODUCTS

#### 2.01 FIRE PROTECTION SYSTEMS

- A. Sprinkler Systems: Conform work to NFPA 13.
- B. Standpipe and Hose Systems: Conform to NFPA 14.
- C. Welding Materials and Procedures: Conform to ASME Code.

#### 2.02 BURIED PIPING

- A. Steel Pipe: ASTM A53/A53M Schedule 40, black, with AWWA C105 polyethylene jacket, or double layer, half-lapped polyethylene tape.
  - 1. Steel Fittings: ASME B16.9, wrought steel, buttwelded; with double layer, half-lapped polyethylene tape.
  - 2. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings.
  - 3. Joints: Welded in accordance with AWS D1.1.
  - 4. Casing: Closed glass cell insulation.
- B. Copper Tube: ASTM B75 (ASTM B75M), O60 or O50 temper.
  - 1. Type: Type K (A).
  - 2. Fittings: ASME B16.18, cast copper alloy, solder joint, pressure type.
  - 3. Joints: AWS A5.8 Classification BCuP-3 or BCuP-4 copper/silver braze.
  - 4. Casing: Closed glass cell insulation.
- C. Cast Iron Pipe: AWWA C151/A21.51.
  - 1. Fittings: AWWA C110, standard thickness.
  - 2. Joints: AWWA C111, rubber gasket.
  - 3. Mechanical Couplings: Shaped composition sealing gasket, steel bolts, nuts, and washers.

#### 2.03 ABOVE GROUND PIPING

- A. Steel Pipe: ASTM A795 Schedule 10 or ASTM A53 Schedule 40, black.
  - 1. Steel Fittings: ASME B16.9, wrought steel, buttwelded.
  - 2. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings.
  - 3. Malleable Iron Fittings: ASME B16.3, threaded fittings.
  - 4. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.
  - 5. Mechanical Formed Fittings: Carbon steel housing with integral pipe stop and O-ring pocked and O-ring, uniformly compressed into permanent mechanical engagement onto pipe.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), H58 drawn.
  - 1. Fittings: ASME B16.18, cast copper alloy, grooved.
  - 2. Mechanical Grooved Couplings: Ductile iron housing with alkyd enamel paint coating clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers.
- C. Cast Iron Pipe: AWWA C151/A21.51.
  - 1. Fittings: AWWA C110/A21.10, standard thickness.
  - 2. Joints: AWWA C111, rubber gasket.
  - 3. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped composition sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.

#### 2.04 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, adjustable swivel, split ring.
- B. Hangers for Pipe Sizes 2 inches and Over: Carbon steel, adjustable, clevis.
- C. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- D. Wall Support for Pipe Sizes to 3 inches: Cast iron hook.
- E. Wall Support for Pipe Sizes 4 inches and Over: Welded steel bracket and wrought steel clamp.
- F. Vertical Support: Steel riser clamp.

- G. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- H. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

#### 2.05 GATE VALVES

- A. Up to and including 2 inches:
  - 1. Bronze body, bronze trim, rising stem, handwheel, solid wedge or disc, threaded ends.
- B. Over 2 inches:
  - 1. Iron body, bronze trim, rising stem pre-grooved for mounting tamper switch, handwheel, OS&Y, solid rubber covered bronze or cast iron wedge, flanged ends.
- C. Over 4 inches:
  - 1. Iron body, bronze trim, non-rising stem with bolted bonnet, solid bronze wedge, flanged ends, iron body indicator post assembly.

#### 2.06 GLOBE VALVES

- A. Up to and including 2 inches:
  - 1. Bronze body, bronze trim, rising stem and handwheel, inside screw, renewable rubber disc, threaded ends, with backseating capacity repackable under pressure.
- B. Over 2 inches:
  - 1. Iron body, bronze trim, rising stem, handwheel, OS&Y, plug-type disc, flanged ends, renewable seat and disc.

#### 2.07 BALL VALVES

- A. Up to and including 2 inches:
  - 1. Bronze two piece body, brass, chrome plated bronze, or stainless steel ball, teflon seats and stuffing box ring, lever handle and balancing stops, threaded ends.
- B. Over 2 inches:
  - 1. Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle or gear drive handwheel for sizes 10 inches and over, flanged.

#### 2.08 BUTTERFLY VALVES

- A. Bronze Body:
  - 1. Stainless steel disc, resilient replaceable seat, threaded or grooved ends, extended neck, handwheel and gear drive and integral indicating device, and built-in tamper proof switch rated 10 amp at 115 volt AC.
- B. Cast or Ductile Iron Body
  - 1. Cast or ductile iron, chrome or nickel plated ductile iron or aluminum bronze disc, resilient replaceable EPDM seat, wafer, lug, or grooved ends, extended neck, handwheel and gear drive and integral indicating device, and internal tamper switch rated 10 amp at 115 volt AC.

#### 2.09 CHECK VALVES

- A. Up to and including 2 inches:
  - 1. Bronze body and swing disc, rubber seat, threaded ends.
- B. Over 2 inches:
  - 1. Iron body, bronze trim, swing check with rubber disc, renewable disc and seat, flanged ends with automatic ball check.
- C. 4 inches and Over:
  - 1. Iron body, bronze disc, stainless steel spring, resilient seal, threaded, wafer, or flanged ends.

#### 2.10 DRAIN VALVES

- A. Compression Stop:
  - 1. Bronze with hose thread nipple and cap.
- B. Ball Valve:
  - 1. Brass with cap and chain, 3/4 inch hose thread.

#### PART 3 EXECUTION

#### 3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

#### 3.02 INSTALLATION

- A. Install sprinkler system and service main piping, hangers, and supports in accordance with NFPA 13.
- B. Install standpipe piping, hangers, and supports in accordance with NFPA 14.
- C. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- D. Install piping to conserve building space, to not interfere with use of space and other work.
- E. Group piping whenever practical at common elevations.
- F. Sleeve pipes passing through partitions, walls, and floors.
- G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- H. Inserts:
  - 1. Provide inserts for placement in concrete formwork.
  - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
  - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
  - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
  - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.
- I. Pipe Hangers and Supports:
  - 1. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
  - 2. Place hangers within 12 inches of each horizontal elbow.
  - 3. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
  - 4. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
  - 5. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
  - 6. Provide copper plated hangers and supports for copper piping.
  - 7. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- J. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

- K. Prepare pipe, fittings, supports, and accessories for finish painting. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding. Refer to Section 09 90 00.
- L. Do not penetrate building structural members unless indicated.
- M. Provide sleeves when penetrating footings, floors, and walls. Seal pipe and sleeve penetrations to achieve fire resistance equivalent to fire separation required.
- N. Escutcheons:
  - 1. Install and firmly attach escutcheons at piping penetrations into finished spaces.
  - 2. Provide escutcheons on both sides of partitions separating finished areas through which piping passes.
  - 3. Use chrome plated escutcheons in occupied spaces and to conceal openings in construction.
- O. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- P. Die cut threaded joints with full cut standard taper pipe threads with red lead and linseed oil or other non-toxic joint compound applied to male threads only.
- Q. Install valves with stems upright or horizontal, not inverted. Remove protective coatings after installation.
- R. Provide gate, ball, or butterfly valves for shut-off or isolating service.
- S. Provide drain valves at main shut-off valves, low points of piping and apparatus.

#### END OF SECTION

#### SECTION 21 05 13

#### MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Single phase electric motors.
- B. Three phase electric motors.

#### 1.02 RELATED REQUIREMENTS

- A. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.
- B. Section 26 29 13 Enclosed Controllers.

#### 1.03 REFERENCE STANDARDS

- A. ABMA STD 9 Load Ratings and Fatigue Life for Ball Bearings.
- B. IEEE 112 IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
- C. NEMA MG 1 Motors and Generators.
- D. NFPA 70 National Electrical Code.

#### 1.04 SUBMITTALS

- A. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- B. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 1/2 horsepower.
- C. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.
- D. Operation Data: Include instructions for safe operating procedures.
- E. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

#### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacture of electric motors, and their accessories, with minimum three years documented product development, testing, and manufacturing experience.
- B. Conform to applicable electrical code, NFPA70, or local energy code.
- C. Provide certificate of compliance from authority having jurisdiction indicating approval of high efficiency motors.
- D. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc. or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

#### 1.07 WARRANTY

A. Provide five year manufacturer warranty for motors larger than 20 horsepower.

#### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Lincoln Motors: www.lincolnmotors.com.
- B. A. O. Smith Electrical Products Company: www.aosmithmotors.com.
- C. Reliance Electric/Rockwell Automation: www.reliance.com.
- D. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Electrical Service: Refer to Section 26 27 17 for required electrical characteristics.
- B. Electrical Service:
  - 1. Motors 1/2 HP and Smaller: 115 volts, single phase, 60 Hz.
  - 2. Motors Larger than 1/2 Horsepower: 460 volts, three phase, 60 Hz.
- C. Construction:
  - 1. Open drip-proof type except where specifically noted otherwise.
  - 2. Design for continuous operation in 40 degrees C environment.
  - 3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
  - 4. Motors with frame sizes 254T and larger: Energy Efficient Type.
- D. Explosion-Proof Motors: UL approved and labelled for hazard classification, with over temperature protection.
- E. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
- F. Wiring Terminations:
  - 1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
  - 2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

#### 2.03 APPLICATIONS

- A. Exception: Motors less than 250 watts, for intermittent service may be the equipment manufacturer's standard and need not conform to these specifications.
- B. Single phase motors for centrifugal pumps: Split phase type.
- C. Single phase motors for pumps: Capacitor start type.
- D. Single phase motors for pumps: Capacitor start, capacitor run type.

#### 2.04 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- A. Starting Torque: Less than 150 percent of full load torque.
- B. Starting Current: Up to seven times full load current.
- C. Breakdown Torque: Approximately 200 percent of full load torque.
- D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
- E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

#### 2.05 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

A. Starting Torque: Exceeding one fourth of full load torque.

MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT StudioJAED Architects & Engineers 21 05 13 - 2

- B. Starting Current: Up to six times full load current.
- C. Multiple Speed: Through tapped windings.
- D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

#### 2.06 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque.
- B. Starting Current: Less than five times full load current.
- C. Pull-up Torque: Up to 350 percent of full load torque.
- D. Breakdown Torque: Approximately 250 percent of full load torque.
- E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.
- G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

#### 2.07 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Starting Torque: Between 1 and 1-1/2 times full load torque.
- B. Starting Current: Six times full load current.
- C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
- E. Insulation System: NEMA Class B or better.
- F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 26 29 13.
- I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- J. Sound Power Levels: To NEMA MG 1.
- K. Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- L. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
- M. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

N. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

#### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C. Check line voltage and phase and ensure agreement with nameplate.

#### 3.02 SCHEDULES

- A. NEMA Open Motor Service Factors.
  - 1. 1/6-1/3 hp:
    - a. 3600 rpm: 1.35.
    - b. 1800 rpm: 1.35.
    - c. 1200 rpm: 1.35.
    - d. 900 rpm: 1.35.
  - 2. 1/2 hp:
    - a. 3600 rpm: 1.25.
    - b. 1800 rpm: 1.25.
    - c. 1200 rpm: 1.25.
    - d. 900 rpm: 1.15.
  - 3. 3/4 hp:
    - a. 3600 rpm: 1.25.
    - b. 1800 rpm: 1.25.
    - c. 1200 rpm: 1.15.
    - d. 900 rpm: 1.15.
  - 4. 1 hp:
    - a. 3600 rpm: 1.25.
    - b. 1800 rpm: 1.15.
    - c. 1200 rpm: 1.15.
    - d. 900 rpm: 1.15.
  - 5. 1.5-150 hp:
    - a. 3600 rpm: 1.15.
    - b. 1800 rpm: 1.15.
    - c. 1200 rpm: 1.15.
    - d. 900 rpm: 1.15.
- B. Three Phase Premium Efficiency, Open Drip-Proof Performance:
  - 1200 rpm.
  - a. 1 hp:

1.

- 1) NEMA Frame: 145T.
- 2) Minimum Percent Power Factor: 72.
- 3) Minimum Percent Efficiency: 82.5
- b. 1-1/2 hp:
  - 1) NEMA Frame: 182T.
  - 2) Minimum Percent Power Factor: 73.
  - 3) Minimum Percent Efficiency: 83.
- c. 2 hp:
  - 1) NEMA Frame: 184T.
  - 2) Minimum Percent Power Factor: 75.
  - 3) Minimum Percent Efficiency: 85.

- d. 3 hp:
  - 1) NEMA Frame: 213T.
  - 2) Minimum Percent Power Factor: 60.
  - 3) Minimum Percent Efficiency: 86.
- e. 5 hp:
  - 1) NEMA Frame: 215T.
  - 2) Minimum Percent Power Factor: 65.
  - 3) Minimum Percent Efficiency: 87.
- f. 7-1/2 hp:
  - 1) NEMA Frame: 254T.
  - 2) Minimum Percent Power Factor: 73.
  - 3) Minimum Percent Efficiency: 89.
- g. 10 hp:
  - 1) NEMA Frame: 256T.
  - 2) Minimum Percent Power Factor: 74.
  - 3) Minimum Percent Efficiency: 89.
- h. 15 hp:
  - 1) NEMA Frame: 284T.
  - 2) Minimum Percent Power Factor: 77.
  - 3) Minimum Percent Efficiency: 90.
- i. 20 hp:
  - 1) NEMA Frame: 286T.
  - 2) Minimum Percent Power Factor: 78.
  - 3) Minimum Percent Efficiency: 90.
- j. 25 hp:
  - 1) NEMA Frame: 324T.
  - 2) Minimum Percent Power Factor: 74.
  - 3) Minimum Percent Efficiency: 91.
- k. 30 hp:
  - 1) NEMA Frame: 326T.
  - 2) Minimum Percent Power Factor: 78.
  - 3) Minimum Percent Efficiency: 91.
- I. 40 hp:
  - 1) NEMA Frame: 364T.
  - 2) Minimum Percent Power Factor: 77.
  - 3) Minimum Percent Efficiency: 93.
- m. 50 hp:
  - 1) NEMA Frame: 365T.
  - 2) Minimum Percent Power Factor: 79.
  - 3) Minimum Percent Efficiency: 93.
- n. 60 hp:
  - 1) NEMA Frame: 404T.
  - 2) Minimum Percent Power Factor: 82.
  - 3) Minimum Percent Efficiency: 93.
- o. 75 hp:
  - 1) NEMA Frame: 405T.
  - 2) Minimum Percent Power Factor: 80.
  - 3) Minimum Percent Efficiency: 93.
- p. 100 hp:
  - 1) NEMA Frame: 444T.

- 2) Minimum Percent Power Factor: 80.
- 3) Minimum Percent Efficiency: 93.
- q. 125 hp:
  - 1) NEMA Frame: 444T.
  - 2) Minimum Percent Power Factor: 84.
  - 3) Minimum Percent Efficiency: 93.
- 2. 1800 rpm.
  - a. 1 hp:
    - 1) NEMA Frame: 143T.
    - 2) Minimum Percent Power Factor: 84.
    - 3) Minimum Percent Efficiency: 82.
  - b. 1-1/2 hp:
    - 1) NEMA Frame: 145T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 84.
  - c. 2 hp:
    - 1) NEMA Frame: 145T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 84.
  - d. 3 hp:
    - 1) NEMA Frame: 182T.
    - 2) Minimum Percent Power Factor: 86.
    - 3) Minimum Percent Efficiency: 86.
  - e. 5 hp:
    - 1) NEMA Frame: 184T.
    - 2) Minimum Percent Power Factor: 87.
    - 3) Minimum Percent Efficiency: 87.
  - f. 7-1/2 hp:
    - 1) NEMA Frame: 213T.
    - 2) Minimum Percent Power Factor: 86.
    - 3) Minimum Percent Efficiency: 88.
  - g. 10 hp:
    - 1) NEMA Frame: 215T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 89.
  - h. 15 hp:
    - 1) NEMA Frame: 256T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 91.
  - i. 20 hp:
    - 1) NEMA Frame: 256T.
    - 2) Minimum Percent Power Factor: 86.
    - 3) Minimum Percent Efficiency: 91.
  - j. 25 hp:
    - 1) NEMA Frame: 284T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 91.
  - k. 30 hp:
    - 1) NEMA Frame: 286T.
    - 2) Minimum Percent Power Factor: 88.

Ι.

- 3) Minimum Percent Efficiency: 92.
- 40 hp:
  - 1) NEMA Frame: 324T.
  - 2) Minimum Percent Power Factor: 83.
  - 3) Minimum Percent Efficiency: 92.
- m. 50 hp:
  - 1) NEMA Frame: 326T.
  - 2) Minimum Percent Power Factor: 88.
  - 3) Minimum Percent Efficiency: 93.
- n. 60 hp:
  - 1) NEMA Frame: 364T.
  - 2) Minimum Percent Power Factor: 88.
  - 3) Minimum Percent Efficiency: 93.
- o. 75 hp:
  - 1) NEMA Frame: 365T.
  - 2) Minimum Percent Power Factor: 88.
  - 3) Minimum Percent Efficiency: 93.
- p. 100 hp:
  - 1) NEMA Frame: 404T.
  - 2) Minimum Percent Power Factor: 83.
  - 3) Minimum Percent Efficiency: 93.
- q. 125 hp:
  - 1) NEMA Frame: 405T.
  - 2) Minimum Percent Power Factor: 86.
  - 3) Minimum Percent Efficiency: 93.
- r. 150 hp:
  - 1) NEMA Frame: 444T.
  - 2) Minimum Percent Power Factor: 85.
  - 3) Minimum Percent Efficiency: 93.
- s. 200 hp:
  - 1) NEMA Frame: 445T.
  - 2) Minimum Percent Power Factor: 85.
  - 3) Minimum Percent Efficiency: 94.
- 3. 3600 rpm.
  - a. 1-1/2 hp:
    - 1) NEMA Frame: 143T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 82.
  - b. 2 hp:
    - 1) NEMA Frame: 145T.
    - 2) Minimum Percent Power Factor: 87.
    - 3) Minimum Percent Efficiency: 82.
  - c. 3 hp:
    - 1) NEMA Frame: 145T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 84.
  - d. 5 hp:
    - 1) NEMA Frame: 182T.
    - 2) Minimum Percent Power Factor: 86.
    - 3) Minimum Percent Efficiency: 85.

- e. 7-1/2 hp:
  - 1) NEMA Frame: 184T.
  - Minimum Percent Power Factor: 88. 2)
  - Minimum Percent Efficiency: 86. 3)
- f. 10 hp:
  - NEMA Frame: 213T. 1)
  - Minimum Percent Power Factor: 86. 2)
  - Minimum Percent Efficiency: 87. 3)
- 15 hp: g.
  - NEMA Frame: 215T. 1)
  - 2) Minimum Percent Power Factor: 89.
  - Minimum Percent Efficiency: 89. 3)
- h. 20 hp:
  - NEMA Frame: 254T. 1)
  - Minimum Percent Power Factor: 89. 2)
  - 3) Minimum Percent Efficiency: 90.
- 25 hp: i.
  - NEMA Frame: 256T. 1)
  - 2) Minimum Percent Power Factor: 92.
  - 3) Minimum Percent Efficiency: 90.
- j. 30 hp:
  - NEMA Frame: 284T. 1)
  - 2) Minimum Percent Power Factor: 91.
  - 3) Minimum Percent Efficiency: 91.
- 40 hp: k.
  - NEMA Frame: 286T. 1)
  - 2) Minimum Percent Power Factor: 92.
  - 3) Minimum Percent Efficiency: 92.
- Ι. 50 hp:
  - 1) NEMA Frame: 324T.
  - 2) Minimum Percent Power Factor: 89.
  - 3) Minimum Percent Efficiency: 93.
- m. 60 hp:
  - NEMA Frame: 326T. 1)
  - Minimum Percent Power Factor: 91. 2)
  - 3) Minimum Percent Efficiency: 93.
- 75 hp: n.
  - 1) NEMA Frame: 364T.
  - 2) Minimum Percent Power Factor: 88.
  - 3) Minimum Percent Efficiency: 93.
- 100 hp: 0.
  - NEMA Frame: 365T. 1)
  - 2) Minimum Percent Power Factor: 88.
  - 3) Minimum Percent Efficiency: 92.
- C. Three Phase Energy Efficient, Totally Enclosed, Fan Cooled Performance: 1.
  - 1200 rpm.
    - 1 hp: a.
      - NEMA Frame: 145T. 1)
      - 2) Minimum Percent Power Factor: 72.
      - 3) Minimum Percent Efficiency: 81.

- b. 1-1/2 hp:
  - 1) NEMA Frame: 182T.
  - 2) Minimum Percent Power Factor: 73.
  - 3) Minimum Percent Efficiency: 83.
- c. 2 hp:
  - 1) NEMA Frame: 184T.
  - 2) Minimum Percent Power Factor: 68.
  - 3) Minimum Percent Efficiency: 85.
- d. 3 hp:
  - 1) NEMA Frame: 213T.
  - 2) Minimum Percent Power Factor: 63.
  - 3) Minimum Percent Efficiency: 86.
- e. 5 hp:
  - 1) NEMA Frame: 215T.
  - 2) Minimum Percent Power Factor: 66.
  - 3) Minimum Percent Efficiency: 86.
- f. 7-1/2 hp:
  - 1) NEMA Frame: 254T.
  - 2) Minimum Percent Power Factor: 68.
  - 3) Minimum Percent Efficiency: 89.
- g. 10 hp:
  - 1) NEMA Frame: 256T.
  - 2) Minimum Percent Power Factor: 75.
  - 3) Minimum Percent Efficiency: 89.
- h. 15 hp:
  - 1) NEMA Frame: 284T.
  - 2) Minimum Percent Power Factor: 72.
  - 3) Minimum Percent Efficiency: 90.
- i. 20 hp:
  - 1) NEMA Frame: 286T.
  - 2) Minimum Percent Power Factor: 76.
  - 3) Minimum Percent Efficiency: 90.
- j. 25 hp:
  - 1) NEMA Frame: 324T.
  - 2) Minimum Percent Power Factor: 71.
  - 3) Minimum Percent Efficiency: 90.
- k. 30 hp:
  - 1) NEMA Frame: 326T.
  - 2) Minimum Percent Power Factor: 79.
  - 3) Minimum Percent Efficiency: 91.
- I. 40 hp:
  - 1) NEMA Frame: 364T.
  - 2) Minimum Percent Power Factor: 78.
  - 3) Minimum Percent Efficiency: 92.
- m. 50 hp:
  - 1) NEMA Frame: 365T.
  - 2) Minimum Percent Power Factor: 81.
  - 3) Minimum Percent Efficiency: 92.
- n. 60 hp:
  - 1) NEMA Frame: 404T.

- 2) Minimum Percent Power Factor: 83.
- 3) Minimum Percent Efficiency: 92.
- o. 75 hp:
  - 1) NEMA Frame: 405T.
  - 2) Minimum Percent Power Factor: 80.
  - 3) Minimum Percent Efficiency: 92.
- p. 100 hp:
  - 1) NEMA Frame: 444T.
  - 2) Minimum Percent Power Factor: 83.
  - 3) Minimum Percent Efficiency: 93.
- q. 125 hp:
  - 1) NEMA Frame: 444T.
  - 2) Minimum Percent Power Factor: 85.
  - 3) Minimum Percent Efficiency: 93.
- 2. 1800 rpm.
  - a. 1 hp:
    - 1) NEMA Frame: 143T.
    - 2) Minimum Percent Power Factor: 84.
    - 3) Minimum Percent Efficiency: 82.
  - b. 1-1/2 hp:
    - 1) NEMA Frame: 145T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 84.
  - c. 2 hp:
    - 1) NEMA Frame: 145T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 84.
  - d. 3 hp:
    - 1) NEMA Frame: 182T.
    - 2) Minimum Percent Power Factor: 83.
    - 3) Minimum Percent Efficiency: 87.
  - e. 5<sup>°</sup>hp:
    - 1) NEMA Frame: 184T.
    - 2) Minimum Percent Power Factor: 83.
    - 3) Minimum Percent Efficiency: 88.
  - f. 7-1/2 hp:
    - 1) NEMA Frame: 213T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 89.
  - g. 10 hp:
    - 1) NEMA Frame: 215T.
    - 2) Minimum Percent Power Factor: 84.
    - 3) Minimum Percent Efficiency: 90.
  - h. 15 hp:
    - 1) NEMA Frame: 254T.
    - 2) Minimum Percent Power Factor: 86.
    - 3) Minimum Percent Efficiency: 91.
  - i. 20 hp:
    - 1) NEMA Frame: 256T.
    - 2) Minimum Percent Power Factor: 85.

- 3) Minimum Percent Efficiency: 91.
- j. 25 hp:
  - 1) NEMA Frame: 284T.
  - 2) Minimum Percent Power Factor: 84.
  - 3) Minimum Percent Efficiency: 92.
- k. 30 hp:
  - 1) NEMA Frame: 286T.
  - 2) Minimum Percent Power Factor: 86.
  - 3) Minimum Percent Efficiency: 93.
- I. 40 hp:
  - 1) NEMA Frame: 324T.
  - 2) Minimum Percent Power Factor: 83.
  - 3) Minimum Percent Efficiency: 93.
- m. 50 hp:
  - 1) NEMA Frame: 326T.
  - 2) Minimum Percent Power Factor: 85.
  - 3) Minimum Percent Efficiency: 93.
- n. 60 hp:
  - 1) NEMA Frame: 364T.
  - 2) Minimum Percent Power Factor: 87.
  - 3) Minimum Percent Efficiency: 93.
- o. 75 hp:
  - 1) NEMA Frame: 365T.
  - 2) Minimum Percent Power Factor: 87.
  - 3) Minimum Percent Efficiency: 93.
- p. 100 hp:
  - 1) NEMA Frame: 405T.
  - 2) Minimum Percent Power Factor: 86.
  - 3) Minimum Percent Efficiency: 94.
- q. 125 hp:
  - 1) NEMA Frame: 444T.
  - 2) Minimum Percent Power Factor: 87.
  - 3) Minimum Percent Efficiency: 94.
- r. 150 hp:
  - 1) NEMA Frame: 445T.
  - 2) Minimum Percent Power Factor: 88.
  - 3) Minimum Percent Efficiency: 94.
- s. 200 hp:
  - 1) NEMA Frame: 447T.
  - 2) Minimum Percent Power Factor: 87.
  - 3) Minimum Percent Efficiency: 95.
- 3. 3600 rpm.
  - a. 1-1/2 hp:
    - 1) NEMA Frame: 143T.
    - 2) Minimum Percent Power Factor: 85.
    - 3) Minimum Percent Efficiency: 82.
    - b. 2 hp:
      - 1) NEMA Frame: 145T.
      - 2) Minimum Percent Power Factor: 87.
      - 3) Minimum Percent Efficiency: 82.

- c. 3 hp:
  - 1) NEMA Frame: 182T.
  - 2) Minimum Percent Power Factor: 87.
  - 3) Minimum Percent Efficiency: 82.
- d. 5 hp:
  - 1) NEMA Frame: 184T.
  - 2) Minimum Percent Power Factor: 88.
  - 3) Minimum Percent Efficiency: 85.
- e. 7-1/2 hp:
  - 1) NEMA Frame: 213T.
  - 2) Minimum Percent Power Factor: 86.
  - 3) Minimum Percent Efficiency: 86.
- f. 10 hp:
  - 1) NEMA Frame: 215T.
  - 2) Minimum Percent Power Factor: 86.
  - 3) Minimum Percent Efficiency: 87.
- g. 15 hp:
  - 1) NEMA Frame: 254T.
  - 2) Minimum Percent Power Factor: 91.
  - 3) Minimum Percent Efficiency: 88.
- h. 20 hp:
  - 1) NEMA Frame: 256T.
  - 2) Minimum Percent Power Factor: 89.
  - 3) Minimum Percent Efficiency: 89.
- i. 25 hp:
  - 1) NEMA Frame: 284T.
  - 2) Minimum Percent Power Factor: 92.
  - 3) Minimum Percent Efficiency: 90.
- j. 30 hp:
  - 1) NEMA Frame: 286T.
  - 2) Minimum Percent Power Factor: 92.
  - 3) Minimum Percent Efficiency: 91.
- k. 40 hp:
  - 1) NEMA Frame: 324T.
  - 2) Minimum Percent Power Factor: 91.
  - 3) Minimum Percent Efficiency: 91.
- I. 50 hp:
  - 1) NEMA Frame: 326T.
  - 2) Minimum Percent Power Factor: 92.
  - 3) Minimum Percent Efficiency: 90.
- m. 60 hp:
  - 1) NEMA Frame: 364T.
  - 2) Minimum Percent Power Factor: 93.
  - 3) Minimum Percent Efficiency: 91.
- n. 75 hp:
  - 1) NEMA Frame: 365T.
  - 2) Minimum Percent Power Factor: 91.
  - 3) Minimum Percent Efficiency: 91.
- o. 100 hp:
  - 1) NEMA Frame: 405T.

- 2) Minimum Percent Power Factor: 92.
- 3) Minimum Percent Efficiency: 92.

#### END OF SECTION

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#### **SECTION 21 05 48**

#### VIBRATION AND SEISMIC CONTROLS FOR EQUIPMENT

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Equipment support bases.
- B. Vibration isolators.
- C. Seismic restraints.

#### 1.02 SUBMITTALS

- A. Product Data:
- B. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each. Indicate seismic control measures.
- C. Manufacturer's Instructions: Indicate installation instructions with special procedures and setting dimensions.

#### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Isolation Technology, Inc: www.isolationtech.com.
- B. Kinetics Noise Control, Inc: www.kineticsnoise.com.
- C. Mason Industries: www.mason-ind.com.

#### 2.02 PERFORMANCE REQUIREMENTS

- A. General:
  - 1. All vibration isolators, base frames and inertia bases to conform to all uniform deflection and stability requirements under all operating loads.

#### 2.03 EQUIPMENT SUPPORT BASES

#### 2.04 VIBRATION ISOLATORS

- A. Open Spring Isolators:
  - 1. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 2. Spring Mounts: Provide with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.
  - 3. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.
  - 4. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- B. Restrained Open Spring Isolators:
  - 1. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 2. Spring Mounts: Provide with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.
  - 3. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.
  - 4. Restraint: Provide heavy mounting frame and limit stops.
  - 5. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.

- C. Closed Spring Isolators:
  - 1. Type : Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.
  - 2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 3. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators, and neoprene side stabilizers with minimum 0.25 inch clearance.
  - 4. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- D. Restrained Closed Spring Isolators:
  - 1. Type : Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.
  - 2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 3. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators, and neoprene side stabilizers with minimum 0.25 inch clearance and limit stops.
  - 4. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- E. Spring Hanger:
  - 1. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 2. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators.
  - 3. Misalignment: Capable of 20 degree hanger rod misalignment.
  - 4. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- F. Neoprene Pad Isolators:

1.

- Rubber or neoprene waffle pads.
  - a. Hardness: 30 durometer.
  - b. Thickness: Minimum 1/2 inch.
  - c. Maximum Loading: 50 psi.
- d. Rib Height: Maximum 0.7 times width.
- 2. Configuration: Single layer.
- 3. Configuration: 1/2 inch thick waffle pads bonded each side of 1/4 inch thick steel plate.
- G. Rubber Mount or Hanger: Molded rubber designed for 0.4 inch deflection with threaded insert.
- H. Glass Fiber Pads: Neoprene jacketed pre-compressed molded glass fiber.
- I. Seismic Snubbers:
  - 1. Type: Non-directional and double acting unit consisting of interlocking steel members restrained by neoprene elements.
  - 2. Elements: Replaceable neoprene, minimum of 0.75 inch thick with minimum 1/8 inch air gap.
  - 3. Capacity: 4 times load assigned to mount groupings at 0.4 inch deflection.
  - 4. Attachment Points and Fasteners: Capable of withstanding 3 times rated load capacity of seismic snubber.

#### PART 3 EXECUTION

#### 3.01 INSTALLATION - GENERAL

- A. Install in accordance with manufacturer's instructions.
- B. Comply with the requirements of NFPA 13.
- C. Bases:
  - 1. Set steel bases for one inch clearance between housekeeping pad and base.
  - 2. Set concrete inertia bases for 2 inches clearance between housekeeping pad and base.
  - 3. Adjust equipment level.
- D. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.
- E. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.
- F. Provide seismic snubbers for all equipment, piping, and ductwork mounted on isolators. Each inertia base shall have minimum of four seismic snubbers located close to isolators. Snub equipment designated for post-disaster use to 0.05 inch maximum clearance. Other snubbers shall have clearance between 0.15 inch and 0.25 inch.
- G. Support piping connections to equipment mounted on isolators using isolators or resilient hangers for scheduled distance.
  - 1. Up to 4 Inches Pipe Size: First three points of support.
  - 2. 5 to 8 Inches Pipe Size: First four points of support.
  - 3. 10 inches Pipe Size and Over: First six points of support.
  - 4. Select three hangers closest to vibration source for minimum 1.0 inch static deflection or static deflection of isolated equipment. Select remaining isolators for minimum 1.0 inch static deflection or 1/2 static deflection of isolated equipment.

#### 3.02 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Inspect isolated equipment after installation and submit report. Include static deflections.

#### 3.03 SCHEDULES

- A. Pipe Isolation Schedule.
  - 1. 1 Inch Pipe Size: Isolate 120 diameters from equipment.
  - 2. 2 Inch Pipe Size: Isolate 90 diameters from equipment.
  - 3. 3 Inch Pipe Size: Isolate 80 diameters from equipment.
  - 4. 4 Inch Pipe Size: Isolate 75 diameters from equipment.
  - 5. 6 Inch Pipe Size: Isolate 60 diameters from equipment.
  - 6. 8 Inch Pipe Size: Isolate 60 diameters from equipment.
  - 7. 10 Inch Pipe Size: Isolate 54 diameters from equipment.
  - 8. 12 Inch Pipe Size: Isolate 50 diameters from equipment.
  - 9. 16 Inch Pipe Size: Isolate 45 diameters from equipment.
  - 10. 24 Inch Pipe Size: Isolate 38 diameters from equipment.
  - 11. Over 24 Inch Pipe Size: As indicated.

#### END OF SECTION

THIS PAGE MILINION MILLING MAIL

#### SECTION 21 05 53

#### **IDENTIFICATION FOR FIRE SUPP. PIPING AND EQUIPMENT**

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Stencils.
- D. Pipe Markers.

#### 1.02 RELATED REQUIREMENTS

A. Section 09 90 00 - Painting and Coating: Identification painting.

#### 1.03 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems.

#### 1.04 SUBMITTALS

- A. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- B. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C. Product Data: Provide manufacturers catalog literature for each product required.
- D. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- E. Project Record Documents: Record actual locations of tagged valves.

#### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Brady Corporation: www.bradycorp.com.
- B. Champion America, Inc: www.Champion-America.com.
- C. Seton Identification Products: www.seton.com/aec.
- D. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved letters.
  - 1. Letter Color: White.
  - 2. Letter Height: 1/4 inch.
  - 3. Background Color: Black.

#### 2.03 TAGS

- A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- C. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

#### 2.04 STENCILS

- A. Stencils: With clean cut symbols and letters of following size:
  - 1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
  - 2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.

- 3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
- 4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
- 5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
- 6. Equipment: 2-1/2 inch high letters.
- B. Stencil Paint: As specified in Section 09 90 00, semi-gloss enamel, colors conforming to ASME A13.1.

#### 2.05 PIPE MARKERS

- A. Color: Conform to ASME A13.1.
- B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

#### 2.06 CEILING TACKS

A. Description: Steel with 3/4 inch diameter color coded head.

#### PART 3 EXECUTION

#### 3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 09 90 00 for stencil painting.

#### 3.02 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Apply stencil painting in accordance with Section 09 90 00.
- D. Install plastic pipe markers in accordance with manufacturer's instructions.
- E. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- G. Identify pumps and valves with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- H. Identify control panels and major control components outside panels with plastic nameplates.
- I. Identify thermostats relating to terminal boxes or valves with nameplates.
- J. Identify valves in main and branch piping with tags.
- K. Tag automatic controls, instruments, and relays. Key to control schematic.
- L. Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including
risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

M. Locate ceiling tacks to locate valves above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

# SECTION 21 12 00 FIRE-SUPPRESSION STANDPIPES

## PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Standpipe system.
- B. Fire department connection.
- C. Fire extinguishers located in hose cabinets.

## 1.02 RELATED REQUIREMENTS

- A. Section 10 44 00 Fire Protection Specialties.
- B. Section 21 05 00 Common Work Results for Fire Suppression: Fire protection piping.
- C. Section 21 05 23 General-Duty Valves for Water-Based Fire-Suppression Piping.
- D. Section 21 05 53 Identification for Fire Supp. Piping and Equipment.
- E. Section 21 30 00 Fire Pumps.
- F. Section 21 13 00 Fire-Suppression Sprinkler Systems.
- G. Section 22 05 53 Identification for Plumbing Piping and Equipment.
- H. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

## 1.03 REFERENCE STANDARDS

- A. FM P7825 Approval Guide; Factory Mutual Research Corporation.
- B. ITS (DIR) Directory of Listed Products.
- C. NFPA 10 Standard for Portable Fire Extinguishers.
- D. NFPA 14 Standard for the Installation of Standpipe and Hose Systems.
- E. UL (DIR) Online Certifications Directory.

## 1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's catalog sheet for equipment indicating rough-in size, finish, and accessories.
- B. Shop Drawings: Indicate supports, components, accessories, and sizes.
  - 1. Submit shop drawings and product data to Caesar Rodney School District's insurance underwriter for approval.
  - 2. Submit proof of approval to StudioJAED.
- C. Project Record Documents: Record actual locations of components.
- D. Operation Data: Include manufacturer's data.
- E. Maintenance Data: Include servicing requirements and test schedule.
- F. Certificates: Provide certificate of compliance from authority having jurisdiction indicating approval of field acceptance tests.

## 1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with NFPA 14. Maintain one copy on site.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum three years experience approved by manufacturer.

# 1.06 PRE-INSTALLATION MEETING

A. Convene one week before starting work of this section.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in shipping packaging until installation.

#### 1.08 EXTRA MATERIALS

A. Provide two extra hose nozzles and hoses.

#### PART 2 PRODUCTS

#### 2.01 FIRE HOSE CABINETS

- A. Hose Cabinets:
  - 1. Style: Recessed mounted.
  - 2. Tub: 16 gage thick steel, prepared for pipe and accessory rough-in.
  - 3. Door: 12 gage thick steel, flush, ; hinged, positive latch device.
  - 4. Finish: Prime Coated.
- B. Hose Rack: Steel with polished chrome finish; swivel type with pins and water stop.
- C. Hose: 1 inch diameter, 50 feet long, of linen hose; mildew and rot-resistant.
- D. Nozzle: Chrome plated brass; combination fog, straight stream, and adjustable shut-off.

#### 2.02 VALVES

- A. Hose Station Valve: Angle type, brass finish, 1-1/2 inch nominal size with automatic ball drip; refer to Section 21 05 00.
- B. Hose Connection Valve: Angle type; brass finish; 2-1/2 inch size, thread to match fire department hardware, 300 psi working pressure, with threaded cap and chain of same material and finish; refer to Section 21 05 00.
- C. Pressure Reducing Valve: Angle type; brass finish with inner hydraulic controls; 1-1/2 inch size, thread to match fire department hardware, 400 psi inlet pressure, with threaded cap and chain of same material and finish; refer to Section 21 05 00.
- D. Hose Connection Valve Cabinets:
  - 1. Style: Recessed mounted.
  - 2. Tub: 16 gage thick steel, prepared for pipe and accessory rough-in.
  - 3. Door: 12 gage thick steel, flush, ; hinged, positive latch device.
  - 4. Finish: Prime Coated.

#### 2.03 FIRE DEPARTMENT CONNECTION

- A. Type: Flush mounted wall type with brass finish.
- B. Outlets: Two way with thread size to suit fire department hardware; threaded dust cap and chain of matching material and finish.
- C. Drain: 3/4 inch automatic drip, outside.
- D. Label: "Standpipe Fire Department Connection".

#### 2.04 FIRE EXTINGUISHERS

- A. General: Comply with NFPA 10; UL listed.
- B. Water Type: Copper container with positive displacement pump and discharge hose.
  - 1. 2-1/2 gallon capacity with 2A rating.
  - 2. 5 gallon capacity with 4A rating.
- C. Carbon Dioxide Type: Insulated handle, hose and horn discharge assembly, self-closing lever or squeeze grip operated, insulated handle.
  - 1. 5 pound capacity with 5BC rating.
  - 2. 10 pound capacity with 10BC rating.
  - 3. 15 pound capacity with 10BC rating.

FIRE-SUPPRESSION STANDPIPES 21 12 00 - 2

- 4. 20 pound capacity with 10BC rating.
- D. Multi-Purpose Dry Chemical Type: Cartridge operated with hose and shut-off nozzle or integral shut-off nozzle.
  - 1. 2-1/2 pound capacity with 1A:10BC rating.
  - 2. 5 pound capacity with 2A:10BC rating.
  - 3. 6 pound capacity with 3A:40BC rating.
  - 4. 10 pound capacity with 4A:60BC rating.
  - 5. 20 pound capacity with 20A:120BC rating.

#### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NFPA 14.
- C. Locate and secure cabinets plumb and level. Establish top of cabinet (inside horizontal) surface 66 inches above finished floor.
- D. Locate hose station valve in cabinet at 60 inches above finished floor.
- E. Connect standpipe system to water source ahead of domestic water connection.
- F. Where static pressure exceeds 100 psi but is less than 100 psi at any hose station, provide pressure orifice disc in discharge of hose station valve to prevent pressure on hose exceeding 90 psi.
- G. Where static pressure exceeds 100 psi at any hose station, provide pressure reducing valve to prevent pressure on hose exceeding 90 psi.
- H. Provide two way fire department outlet connection on roof.
- I. Flush entire system of foreign matter.

## 3.02 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Section 01 40 00.
- B. Test entire system in accordance with NFPA 14.
- C. Test shall be witnessed by authority having jurisdiction.

# SECTION 21 13 00 FIRE SUPPRESSION SPRINKLERS

#### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Wet-pipe sprinkler system.
- B. System design, installation, and certification.

## 1.02 RELATED REQUIREMENTS

- A. Section 28 31 00 Fire Detection and Alarm.
- B. Section 21 05 00 Common Work Results for Fire Suppression: Pipe, fittings, and valves.
- C. Section 21 05 48 Vibration and Seismic Controls for Equipment.
- D. Section 21 05 53 Identification for Fire Supp. Piping and Equipment.
- E. Section 21 30 00 Fire Pumps.
- F. Section 21 12 00 Fire-Suppression Standpipes.
- G. Section 14 91 00 Facility Chutes: Sprinkler heads inside chutes.
- H. Section 22 05 48 Vibration and Seismic Controls for Plumbing Piping and Equipment.
- I. Section 22 05 53 Identification for Plumbing Piping and Equipment.
- J. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

## 1.03 REFERENCE STANDARDS

- A. FM P7825 Approval Guide; Factory Mutual Research Corporation.
- B. ITS (DIR) Directory of Listed Products.
- C. NFPA 13 Standard for the Installation of Sprinkler Systems.
- D. NFPA 13R Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies.
- E. UL (DIR) Online Certifications Directory.

## 1.04 SUBMITTALS

- A. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- B. Shop Drawings:
  - 1. Submit preliminary layout of finished ceiling areas indicating only sprinkler locations coordinated with ceiling installation.
  - 2. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
  - 3. Submit shop drawings and hydraulic calculations to authority having jurisdiction and Fire Marshall for approval. Submit proof of approval to StudioJAED.
- C. Samples: Submit one of each style of sprinkler specified.
- D. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.
- E. Manufacturer's Certificate: Certify that system has been tested and meets or exceeds specified requirements and code requirements.
- F. Operation and Maintenance Data: Include components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

- G. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. Extra Sprinklers: Type and size matching those installed, in quantity required by referenced NFPA design and installation standard.
  - 2. Sprinkler Wrenches: For each sprinkler type.

#### 1.05 QUALITY ASSURANCE

- A. Maintain one copy of referenced design and installation standard on site.
- B. Conform to UL requirements.
- C. Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this type of work and licensed in Delaware.
- D. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- E. Installer Qualifications: Company specializing in performing the work of this section with minimum three years experience approved by manufacturer.
- F. Equipment and Components: Provide products that bear UL label or marking.
- G. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc. or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

#### 1.06 MOCK-UP

- A. Provide components for installation in mock-up.
- B. Mock-up may not remain as part of the Work.

#### 1.07 PRE-INSTALLATION MEETING

A. Convene one week before starting work of this section.

#### 1.08 DELIVERY, STORAGE, AND HANDLING

A. Store products in shipping containers and maintain in place until installation. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

#### 1.09 EXTRA MATERIALS

- A. Provide extra sprinklers of type and size matching those installed, in quantity required by referenced NFPA design and installation standard.
- B. Provide suitable wrenches for each sprinkler type.
- C. Provide metal storage cabinet located adjacent to alarm valve.

## PART 2 PRODUCTS

#### 2.01 SPRINKLER SYSTEM

- A. Sprinkler System: Provide coverage for building areas noted.
- B. Occupancy: comply with NFPA 13.
- C. Water Supply: Determine volume and pressure from water flow test data.1. Revise design when test data available prior to submittals.
- D. Interface system with building fire and smoke alarm system.
- E. Provide fire department connections where indicated.
- F. Storage Cabinet for Spare Sprinklers and Tools: Steel, located adjacent to alarm valve.

#### 2.02 SPRINKLERS

- A. Suspended Ceiling Type: Concealed pendant type with matching push on, clamp on or screw on escutcheon plate.
  - 1. Finish: Enamel, color as selected.
    - a. Within Standard Acoustical Tile Ceilings: White with White Estucheon Plate
    - b. Within Accent Acoustical Clouds: Chrome Plated with Chrome Plated Estucheon Plate
  - 2. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- B. Exposed Area Type: Standard upright type with guard.
  - 1. Finish: Chrome plated.
  - 2. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- C. Sidewall Type: Standard, Semi-recessed or Recessed horizontal sidewall type with matching push on escutcheon plate and guard.
  - 1. Finish: Chrome plated.
  - 2. Escutcheon Plate Finish: Chrome plated.
  - 3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- D. Dry Sprinklers: Standard, Recessed or Exposed pendant type with matching push on escutcheon plate.
  - 1. Finish: Chrome plated.
  - 2. Escutcheon Plate Finish: Chrome plated.
  - 3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- E. Guards: Finish to match sprinkler finish.
- F. Spray Nozzles: Brass with solid cone discharge, 30 degrees of arc with blow-off dust cap.

#### 2.03 PIPING SPECIALTIES

- A. Wet Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced clapper to automatically actuate water motor alarm, pressure retard chamber and variable pressure trim with the following additional capabilities and features:
  - 1. Activate electric alarm.
  - 2. Test and drain valve.
  - 3. Replaceable internal components without removing valve from installed position.
- B. Dry Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced clapper to automatically actuate water motor alarm, accelerator, and with the following additional capabilities and features:
  - 1. Activate electric alarm.
  - 2. Test and drain valve.
  - 3. Externally resettable.
  - 4. Replaceable internal components without removing valve from installed position.
- C. Wet Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced clapper to automatically actuate water motor alarm and electric alarm, with pressure retard chamber and variable pressure trim; with test and drain valve.
- D. Flooding Deluge Valve: Gate type valve with rubber faced disc actuated manually with water motor alarm and electric alarm, with alarm testing trim.
- E. Preaction Valve:
  - 1. Operated by detection system listed for releasing service and independent of building fire alarm system with provisions for local, manual, and indicated remote releases.
  - 2. Incorporate mechanical latching mechanism incorporating valve clappers independent of system water pressure fluctuations.

- 3. Provide test detection device for each actuation circuit adjacent to each controlled valve in accordance with NFPA 13.
- F. Backflow Preventer: Reduced pressure principle valve assembly backflow preventer with drain and OS & Y gate valve on each end.
- G. Test Connections:
  - 1. Inspector's Test Connection for Preaction Systems:
    - a. Provide test connections approximately 6 ft above floor for each or portion of each sprinkler system equipped with an alarm device, located at the most remote part of each system.
    - b. Route test connection to an open-site drain location, excluding janitor sinks, accepting full flow without negative consequences.
    - c. Supply discharge orifice with same size as corresponding sprinkler orifice.
    - d. Limit vertical height of exterior wall penetration to 2 ft above finished grade.
  - 2. Backflow Preventer Test Connection:
    - a. Provide downstream of the backflow prevention assembly, listed hose valves with 2.5 inch National Standard male hose threads with cap and chain.
    - b. Furnish one valve for each 250 gpm of system demand or fraction thereof.
    - c. Provide permanent sign reading "Test Valve" in accordance with Section 22 05 53.
- H. Water Motor Alarm: Hydraulically operated impeller type alarm with aluminum alloy chrome plated gong and motor housing, nylon bearings, and inlet strainer.

## 2.04 PRESSURE MAINTENANCE PUMP

- A. Type: Close coupled motor and positive displacement pump unit.
- B. Construction: Bronze with stainless steel shafts, carbon bearings.
- C. Motor: Open drip proof, permanently lubricated.
- D. Electrical Characteristics:
  - 1. See Drawings.
- E. Accessories: Include flexible hose connections, inlet strainer, and relief valve.
- F. Operation: Manual or Automatic with pressure switch actuation.

## PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install in accordance with referenced NFPA design and installation standard.
- B. Install equipment in accordance with manufacturer's instructions.
- C. Place pipe runs to minimize obstruction to other work.
- D. Place piping in concealed spaces above finished ceilings.
- E. Center sprinklers in two directions in ceiling tile and provide piping offsets as required.
- F. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.
- G. Install and connect to fire pump system in accordance with Section 21 30 00.
- H. Flush entire piping system of foreign matter.
- I. Install guards on sprinklers where indicated.
- J. Hydrostatically test entire system.
- K. Require test be witnessed by Fire Marshal and authority having jurisdiction.

# 3.02 INTERFACE WITH OTHER PRODUCTS

A. Ensure required devices are installed and connected as required to fire alarm system.

# SECTION 21 30 00 FIRE PUMPS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Fire pump package, including electric motor drive, controller, and accessories.
- B. System maintenance.

## 1.02 RELATED REQUIREMENTS

- A. Section 21 05 13 Motor Requirements for Fire Suppression Equipment.
- B. Section 21 05 48 Vibration and Seismic Controls for Equipment.
- C. Section 22 07 16 Plumbing Equipment Insulation.
- D. Section 21 05 00 Common Work Results for Fire Suppression: Fire protection piping.
- E. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

## 1.03 REFERENCE STANDARDS

- A. NEMA MG 1 Motors and Generators.
- B. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. NFPA 13 Standard for the Installation of Sprinkler Systems.
- D. NFPA 20 Standard for the Installation of Stationary Pumps for Fire Protection.
- E. UL (DIR) Online Certifications Directory.
- F. UL 448 Centrifugal Stationary Pumps for Fire-Protection Service.
- G. UL 778 Standard for Motor-Operated Water Pumps.
- H. UL 1478 Fire Pump Relief Valves.

## 1.04 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Convene one week before starting work of this section.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturers literature including general assembly, pump curves showing performance characteristics with pump and system, operating point indicated, NPSH curve, controls, wiring diagrams, and service connections.
- C. Shop Drawings: Indicate layout, general assembly, components, dimensions, weights, clearances, and methods of assembly.
- D. Test Reports: Indicate results of hydrostatic test and field acceptance tests.
- E. Manufacturer's Instructions: Indicate support details, connection requirements, for fire pump system.
- F. Project Record Documents: Record actual locations of components and accessories.
- G. Certificates: Certify that fire pumps meet or exceed specified requirements at specified operating conditions and that the installation complies with regulatory requirements. Submit summary and results of shop tests performed in accordance with NFPA 20.
- H. Operation Data: Include manufacturers instructions, start-up data, trouble-shooting check lists, for pumps, drivers, and controllers.
- I. Maintenance Data: Include manufacturers literature, cleaning procedures, replacement parts lists, and repair data for pumps, drivers and controllers.

- J. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
  - 2. Extra Pump Gaskets/Screens/Seals: One set for each different pump model.

## 1.06 QUALITY ASSURANCE

- A. Comply with NFPA 20 and NFPA 13; where requirements differ comply with the most stringent.
- B. Maintain on site at all times one copy of each design and installation standard referenced.
- C. Design fire pump system under direct supervision of a Professional Engineer experienced in design of this Work and licensed at Delaware.
- D. Equipment and Components: Bearing UL label or marking.
- E. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- F. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- G. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years experience. approved by manufacturer.
- H. Provide certificate of compliance from authority have jurisdiction indicating approval of field acceptance tests.

## 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fire pumps and components in factory packing. Comply with manufacturer's rigging and installation instructions.
- B. Protect fire pumps and components from physical damage including effects of weather, water, and construction debris.
- C. Provide temporary inlet and outlet caps, and maintain in place until installation.

## PART 2 PRODUCTS

## 2.01 FIRE PUMPS

- A. Fire Pumps: Vertical in-line type; UL 448 and UL 778; single stage, close coupled, radially or horizontally split casing, for in-line mounting, for 250 psi.
  - 1. Casing: Cast or ductile iron, with suction and discharge gage port, casing wear ring, seal flush connection, drain plug, flanged suction and discharge.
  - 2. Impeller: Bronze, fully enclosed, keyed directly to motor shaft.
  - 3. Shaft: Solid alloy steel with bronze sleeve.
  - 4. Seal: Packing gland with minimum four rings graphite impregnated packing and bronze lantern rings, 230 degrees F maximum continuous operating temperature.
- B. Fire Pump Accessories:
  - 1. Eccentric suction reducer and OS&Y gate or butterfly valve on suction side of pump.
  - 2. Concentric increaser and check valve in pump discharge and OS&Y gate or butterfly valve on system side of check valve.
  - 3. Fire pump bypass fitted with OS&Y gate or butterfly valves and check valve.
  - 4. Main relief valve, UL 1478, and enclosed type waste cone.
  - 5. Suction pressure gage, 4-1/2 inch diameter dial with snubber, valve cock and lever handle.
  - 6. Discharge pressure gage mounted on board attached to pump, with snubber, valve cock and lever handle.
  - 7. 3/4 inch casing relief valve.
  - 8. Float operated 3/4 inch automatic air release valve.
  - 9. Hose valve manifold with 2-1/2 inch hose gate valves with caps and chains.

10. Flow metering system for closed loop testing.

#### 2.02 ELECTRIC MOTOR DRIVE

- A. Motor: Squirrel cage induction type, NEMA MG 1; in open drip proof NEMA 250 enclosure, 3500 rpm. Refer to Section 22 05 13.
- B. Controller: Limited service type with auto-transformer starter, in NEMA 250 enclosure, including the following:
  - 1. Disconnect Switch: Externally operable, quick break type.
  - 2. Circuit Breaker: Comply with NFPA 20; minimum 65,000 amperes interrupting capacity.
  - 3. Motor Starter: Energized automatically through pressure switch or manually by externally operable handle.
  - 4. Running Period Timer: Keeps motor in operation when started automatically, for a minimum of seven minutes.
  - 5. Pilot Lamp: Indicates circuit breaker closed and power available.
  - 6. Test Accessories: Ammeter test link and voltmeter test studs.
  - 7. Alarm Relay: Energizes alarm to indicate circuit breaker open or power failure.
  - 8. Switch Relay: For remote start.
  - 9. Manual Selector Station: On enclosure marked "Automatic" and "Non-Automatic."

## PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Install in accordance with NFPA 20.
- B. Provide access space around pumps for service; no less than minimum as recommended by manufacturer.
- C. Install piping in accordance with Section 21 05 00. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For base mounted pumps, provide supports under elbows on pump suction and discharge.
- D. Provide drains for bases and seals, piped to and discharging into floor drains.
- E. Mount unit on vibration isolators. Refer to Section 21 05 48.
- F. Insulate piping associated with pump, pump casing and exhaust silencer. Refer to Section 21 07 19 and Section 22 07 16.
- G. Provide for connection to electrical service. Refer to Section 26 27 17.
- H. Lubricate pumps before start-up.

## 3.02 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Section 01 40 00.
- B. Perform field acceptance tests as specified in NFPA 20.
- C. Perform field acceptance tests in the presence of Fire Marshal.

#### 3.03 CLOSEOUT ACTIVITIES

A. Demonstrate automatic operation of system including verification of pressure switch set points.

## 3.04 MAINTENANCE

- A. See Section 01 70 00 Execution Requirements, for additional requirements relating to maintenance service.
- B. Provide service and maintenance of equipment installed under this section for one year from the Date of Substantial Completion.

#### SECTION 22 05 16

#### EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Flexible pipe connectors.
- B. Expansion joints and compensators.
- C. Pipe loops, offsets, and swing joints.

#### 1.02 RELATED REQUIREMENTS

- A. Section 21 05 00 Common Work Results for Fire Suppression.
- B. Section 22 10 05 Plumbing Piping.

#### 1.03 REFERENCE STANDARDS

- A. ASTM A269/A269M Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
- B. EJMA (STDS) EJMA Standards.

#### 1.04 SUBMITTALS

- A. Product Data:
  - 1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
  - 2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
- B. Design Data: Indicate selection calculations.
- C. Manufacturer's Instructions: Indicate manufacturer's installation instructions, special procedures, and external controls.
- D. Project Record Documents: Record installed locations of flexible pipe connectors, expansion joints, anchors, and guides.
- E. Maintenance Data: Include adjustment instructions.

#### 1.05 REGULATORY REQUIREMENTS

A. Conform to UL or Warnock Hersey requirements.

## 1.06 EXTRA MATERIALS

A. Supply two sets of packing for each packed expansion joint.

#### PART 2 PRODUCTS

## 2.01 FLEXIBLE PIPE CONNECTORS - STEEL PIPING

- A. Manufacturers:
  - 1. Mercer Rubber Company: www.mercer-rubber.com.
  - 2. Metraflex Company: www.metraflex.com.
  - 3. Substitutions: See Section 01 60 00 Product Requirements.
- B. Inner Hose: Carbon Steel, Stainless Steel or Bronze.
- C. Exterior Sleeve: Single braided or Double braided, stainless steel or bronze.
- D. Exterior Sleeve: None.
- E. Pressure Rating: 125 psi and 450 degrees F or 200 psi and 250 degrees F.

- F. Joint: As specified for pipe joints.
- G. Size: Use pipe sized units.
- H. Maximum offset: 3/4 inch on each side of installed center line.

## 2.02 FLEXIBLE PIPE CONNECTORS - COPPER PIPING

- A. Manufacturer:
  - 1. Mercer Rubber Company: www.mercer-rubber.com.
  - 2. Metraflex Company: www.metraflex.com.
  - 3. Substitutions: See Section 01 60 00 Product Requirements.
- B. Inner Hose: Bronze.
- C. Exterior Sleeve: Braided bronze.
- D. Pressure Rating: 125 psi and 450 degrees F or 200 psi and 250 degrees F.
- E. Joint: As specified for pipe joints.
- F. Size: Use pipe sized units.
- G. Maximum offset: 3/4 inch on each side of installed center line.
- H. Application: Copper piping.

#### 2.03 EXPANSION JOINTS - STEEL WITH PACKED SLIDING SLEEVE

- A. Working Pressure and Temperature: Class 150 or Class 300.
- B. Joint: As specified for pipe joints.
- C. Size: Use pipe sized units.
- D. Application: Steel piping 2 inches and over.

## 2.04 EXPANSION JOINTS - COPPER WITH PACKED SLIDING SLEEVE

- A. Working Pressure: 125 psi.
- B. Maximum Temperature: 250 degrees F.
- C. Joint: As specified for pipe joints.
- D. Size: Use pipe sized units.
- E. Application: Copper or steel piping 2 inches and over.

#### 2.05 ACCESSORIES

- A. Stainless Steel Pipe: ASTM A269.
- B. Pipe Alignment Guides:
  - 1. Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch thick insulation, minimum 3 inches travel.
- C. Swivel Joints:
  - 1. Fabricated steel, Bronze, Ductile Iron or Cast steel body, double ball bearing race, field lubricated, with rubber (Buna-N) o-ring seals.

# PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with EJMA (Expansion Joint Manufacturers Association) Standards.
- C. Install flexible pipe connectors on pipes connected to vibration isolated equipment. Provide line size flexible connectors.

- D. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- E. Anchor pipe to building structure where indicated. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.
- F. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required.
- G. Substitute grooved piping for vibration isolated equipment instead of flexible connectors. Grooved piping need not be anchored.

# SECTION 22 05 19 METERS AND GAGES FOR PLUMBING PIPING

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Positive displacement meters.
- B. Pressure gages and pressure gage taps.
- C. Thermometers and thermometer wells.
- D. Static pressure gages.
- E. Filter gages.

## 1.02 REFERENCE STANDARDS

- A. ASME B40.100 Pressure Gauges and Gauge Attachments.
- B. ASME MFC-3M Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi.
- C. ASTM E1 Standard Specification for ASTM Liquid-in-Glass Thermometers.
- D. ASTM E77 Standard Test Method for Inspection and Verification of Thermometers.
- E. AWWA C700 Cold-Water Meters -- Displacement Type, Metal Alloy Main Case.
- F. AWWA C701 Cold-Water Meters -- Turbine Type, for Customer Service.
- G. AWWA C702 Cold-Water Meters -- Compound Type.
- H. AWWA C706 Direct-Reading, Remote-Registration Systems for Cold Water Meters; American Water Works Association (ANSI/AWWA C706).
- I. AWWA M6 Water Meters -- Selection, Installation, Testing, and Maintenance.
- J. UL 393 Indicating Pressure Gauges for Fire-Protection Service.

#### 1.03 SUBMITTALS

- A. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.
- B. Project Record Documents: Record actual locations of components and instrumentation.
- C. Operation and Maintenance Data: .

#### 1.04 FIELD CONDITIONS

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

#### 1.05 EXTRA MATERIALS

- A. Supply two bottles of red gage oil for static pressure gages.
- B. Supply two pressure gages with pulsation damper or dial thermometers.

## PART 2 PRODUCTS

#### 2.01 LIQUID FLOW METERS

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: www.dwyer-inst.com.
  - 2. Venture Measurement, a Danaher Corporation Company: www.venturemeasurement.com.
  - 3. Omega Meters: www.omega.com.
- B. Description: Totalizing turbine-type flow meter with rate indication and pulse output.
  1. Maximum Working Pressure:

- a. PVC: 150 psi
- b. Carbon Steel: 200 psi
- 2. Maximum Temperature:
  - a. PVC: 49°C (120°F)
  - b. Carbon Steel: 93°C (200°F)
- 3. Accuracy: ±1% FS
- 4. Signal: Squarewave pulse
- 5. Power :6 to 24 Vdc
- 6. Materials
  - a. Meter Body: PVC or carbon steel
  - b. Flanges: Van Stone w/steel backing flange for PVC bodies, 150# ANSI for carbon steel bodies
  - c. Turbine Rotor: PVDF
  - d. Rotor Shafts: Zirconia ceramic
  - e. Bearings: Sapphire journal, ruby ball
- 7. Display
  - a. Power: 11 to 24 Vdc, 20 mA max
  - b. Rate: 8-digit autorange
  - c. Total: 8-digit, selectable decimal
  - d. Memory: Non-volatile (no battery needed)
  - e. Pulse Output: 0.1 sec, open collector Analog Option 4 to 20 mA, user-programmable
- 8. Transmitter
  - a. Output: 4 to 20 mA
  - b. Loop Power: 12 to 26 Vdc (isolated)
  - c. Accuracy: ±1%
  - d. Response Time: 3 sec, 95% FS

# 2.02 PRESSURE GAGES

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: www.dwyer-inst.com.
  - 2. Moeller Instrument Co., Inc: www.moellerinstrument.com.
  - 3. Omega Engineering, Inc: www.omega.com.
- B. Pressure Gages: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
  - 1. Case: Steel with brass bourdon tube.
  - 2. Size: 4-1/2 inch diameter.
  - 3. Size: 2 inch diameter.
  - 4. Mid-Scale Accuracy: One percent.
  - 5. Scale: Psi.

## 2.03 PRESSURE GAGE TAPPINGS

- A. Gage Cock: Tee or lever handle, brass for maximum 150 psi.
- B. Needle Valve: Brass or Stainless Steel, 1/4 inch NPT for minimum 150 psi.
- C. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.
- D. Syphon: Steel, Schedule 40, 1/4 inch angle or straight pattern.

## 2.04 STEM TYPE THERMOMETERS

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: www.dwyer-inst.com.
  - 2. Omega Engineering, Inc: www.omega.com.

- 3. Weksler Glass Thermometer Corp: www.wekslerglass.com.
- 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Thermometers Fixed Mounting: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish.
  - 1. Size: 9 inch scale.
  - 2. Window: Clear Lexan.
  - 3. Size: 9 inch scale.
  - 4. Window: Clear glass or Lexan.
  - 5. Accuracy: 2 percent, per ASTM E77.
  - 6. Calibration: Degrees F.
- C. Thermometers Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
  - 1. Size: 9 inch scale.
  - 2. Window: Clear Lexan.
  - 3. Size: 9 inch scale.
  - 4. Window: Clear glass or Lexan.
  - 5. Stem: 3/4 inch NPT brass.
  - 6. Accuracy: 2 percent, per ASTM E77.
  - 7. Calibration: Degrees F.

#### 2.05 THERMOMETER SUPPORTS

- A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

#### 2.06 TEST PLUGS

- A. Test Plug: 1/4 inch or 1/2 inch brass or stainless steel fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with Nordel core for temperatures up to 350 degrees F.
- B. Test Kit: Carrying case, internally padded and fitted containing one 2-1/2 inch diameter pressure gages, one gage adapters with 1/8 inch probes, two 1 inch dial thermometers.

#### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install positive displacement meters with isolating valves on inlet and outlet to AWWA M6. Provide full line size valved bypass with globe valve for liquid service meters.
- C. Provide one pressure gage per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gage.
- D. Install pressure gages with pulsation dampers. Provide gage cock or needle valve to isolate each gage. Extend nipples and siphons to allow clearance from insulation.
- E. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- F. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets. Refer to Section 23 09 43.

- G. Coil and conceal excess capillary on remote element instruments.
- H. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- I. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- J. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- K. Locate test plugs adjacent thermometers and thermometer sockets, adjacent to pressure gages and pressure gage taps, adjacent to control device sockets or where indicated.

#### 3.02 SCHEDULES

- A. Positive Displacement Meters, Location:
  - 1. Domestic cold water.
  - 2. Expansion tank make-up.
- B. Pressure Gages, Location and Scale Range:
  - 1. Pumps, 0 to 100 psi.
  - 2. Expansion tanks, 0 to 100 psi.
  - 3. Sprinkler system, 0 to 100 psi.
  - 4. Backflow preventers, 0 to 100 psi.
- C. Pressure Gage Tappings, Location:
  - 1. Control valves 3/4 inch & larger inlets and outlets.
  - 2. Major coils inlets and outlets.
  - 3. Heat exchangers inlets and outlets.
- D. Stem Type Thermometers, Location and Scale Range:
  - 1. Domestic hot water supply and recirculation, 0 to 220 degrees F.

#### SECTION 22 05 48

# VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT SEE SPECIFICATION SECTION 23 05 48

## SECTION 22 05 53

## IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Stencils.
- D. Pipe Markers.

## 1.02 RELATED REQUIREMENTS

- A. Section 09 90 00 Painting and Coating: Identification painting.
- B. Section 22 60 05 Medical Air, Gas, and Vacuum Systems: Supply of pipe labels for placement under this section.

## 1.03 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems; The American Society of Mechanical Engineers.

## 1.04 SUBMITTALS

- A. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- B. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C. Product Data: Provide manufacturers catalog literature for each product required.
- D. Samples: Submit two labels; tags in size.
- E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- F. Project Record Documents: Record actual locations of tagged valves.

## PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Brady Corporation: www.bradycorp.com.
- B. Champion America, Inc: www.Champion-America.com.
- C. Seton Identification Products: www.seton.com/aec.
- D. Substitutions: See Section 01 60 00 Product Requirements.

## 2.02 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved letters.
  - 1. Letter Color: Black.
  - 2. Letter Height: 1/2 inch.
  - 3. Background Color: Yellow.

## 2.03 TAGS

- A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter or square.
- B. Metal Tags: Brass, aluminum, or stainless steel with stamped letters; tag size minimum 1-1/2 inch diameter or square with smooth edges.
- C. Chart: Typewritten letter size list in anodized aluminum frame.

## 2.04 STENCILS

- A. Stencils: With clean cut symbols and letters of following size:
  - 1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
  - 2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
  - 3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
  - 4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
  - 5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
  - 6. Ductwork and Equipment: 2-1/2 inch high letters.
- B. Stencil Paint: As specified in Section 09 90 00, semi-gloss enamel, colors conforming to ASME A13.1.

## 2.05 PIPE MARKERS

- A. Comply with ASME A13.1.
- B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

#### 2.06 CEILING TACKS

- A. Description: Steel with 3/4 inch diameter color coded head.
- B. Color code as follows:
  - 1. HVAC Equipment: Yellow.
  - 2. Fire Dampers and Smoke Dampers: Red.
  - 3. Plumbing Valves: Green.
  - 4. Heating/Cooling Valves: Blue.

## PART 3 EXECUTION

#### 3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 09 90 00 for stencil painting.

#### 3.02 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Apply stencil painting in accordance with Section 09 90 00.
- D. Install plastic pipe markers in accordance with manufacturer's instructions.
- E. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

- G. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates or stencil painting. Small devices, such as in-line pumps, may be identified with tags.
- H. Identify control panels and major control components outside panels with plastic nameplates.
- I. Identify thermostats relating to terminal boxes or valves with nameplates.
- J. Identify valves in main and branch piping with tags.
- K. Identify air terminal units and radiator valves with numbered tags.
- L. Tag automatic controls, instruments, and relays. Key to control schematic.
- M. Identify piping, concealed or exposed, with plastic pipe markers or plastic tape pipe markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- N. Identify ductwork with plastic nameplates or stenciled painting. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
- O. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

# SECTION 22 07 16 PLUMBING EQUIPMENT INSULATION

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Equipment insulation.
- B. Covering.

## 1.02 RELATED REQUIREMENTS

- A. Section 09 90 00 Painting and Coating: Painting insulation covering.
- B. Section 22 05 53 Identification for Plumbing Piping and Equipment.
- C. Section 22 10 05 Plumbing Piping: Placement of hangers and hanger inserts.
- D. Section 23 21 13 Hydronic Piping: Placement of hangers and hanger inserts.
- E. Section 23 21 14 Hydronic Specialties.

## 1.03 REFERENCE STANDARDS

- A. ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
- B. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- C. ASTM B209M Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].
- D. ASTM C177 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- E. ASTM C195 Standard Specification for Mineral Fiber Thermal Insulating Cement.
- F. ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- G. ASTM C592 Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type).
- H. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.
- I. ASTM E96/E96M Standard Test Methods for Water Vapor Transmission of Materials.
- J. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association.
- K. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials.

## 1.04 SUBMITTALS

- A. See Gilbane Project Manual.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.
- C. Samples: Submit two samples of any representative size illustrating each insulation type.
- D. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

#### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with not less than three years of experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum three years of experience and approved by manufacturer.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

#### 1.07 FIELD CONDITIONS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

#### PART 2 PRODUCTS

## 2.01 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION

A. Surface Burning Characteristics: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.

#### 2.02 GLASS FIBER, FLEXIBLE

- A. Manufacturers:
  - 1. Knauf Insulation; : www.knaufusa.com.
  - 2. Johns Manville Corporation; : www.jm.com.
  - 3. Owens Corning Corp; : www.owenscorning.com.
  - 4. CertainTeed Corporation; : www.certainteed.com.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
- B. Insulation: ASTM C553; flexible, noncombustible.
  - 1. 'K' Value: 0.36 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
  - 2. Maximum Service Temperature: 450 degrees F, 850 degrees F, 1000 degrees F or 1200 degrees F.
  - 3. Maximum Water Vapor Sorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film or Vinyl.
  - 1. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  - 2. Secure with self-sealing longitudinal laps and butt strips.
  - 3. Secure with outward clinch expanding staples and vapor barrier mastic.
- D. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- E. Vapor Barrier Lap Adhesive:
  - 1. Compatible with insulation.
- F. Insulating Cement/Mastic:
  - 1. ASTM C195; hydraulic setting on mineral wool.

## 2.03 GLASS FIBER, RIGID

- A. Manufacturer:
  - 1. Knauf Insulation: www.knaufusa.com.
  - 2. Johns Manville Corporation: www.jm.com.
  - 3. Owens Corning Corp: www.owenscorning.com.
  - 4. CertainTeed Corporation; www.certainteed.com.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
- B. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.

PLUMBING EQUIPMENT INSULATION 22 07 16 - 2

- 1. 'K' Value: 0.25 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
- 2. Maximum Service Temperature: 850 degrees F or 1200 degrees F.
- 3. Maximum Water Vapor Sorption: 5.0 percent by weight.
- 4. Maximum Density: 8.0 lb/cu ft or 12.0 lb/cu ft.
- C. Vapor Barrier Jacket:
  - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film or Vinyl.
  - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  - 3. Secure with self-sealing longitudinal laps and butt strips.
  - 4. Secure with outward clinch expanding staples and vapor barrier mastic.
- D. Facing: 1 inch galvanized steel hexagonal wire mesh stitched on one face of insulation.
- E. Vapor Barrier Lap Adhesive:
  - 1. Compatible with insulation.
- F. Insulating Cement/Mastic:
  - 1. ASTM C195; hydraulic setting on mineral wool.

## 2.04 CELLULAR GLASS

- A. Manufacturer:
  - 1. Pittsburgh Corning Corporation: www.foamglasinsulation.com.
  - 2. Substitutions: See Gilbane Project Manual.
- B. Insulation: ASTM C552, Grade 2.
  - 1. 'K' Value: 0.41 at 100 degrees F.
  - 2. Service Temperature: Up to 900 degrees F.
  - 3. Water Vapor Permeability: 0.005 perm inch.
  - 4. Water Absorption: 0.2 percent by volume, maximum.
  - 5. Density: Minimum 6.80 lb/cu ft.

## 2.05 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Manufacturer:
  - 1. Armacell International: www.armacell.com.
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C 534 Grade 3, Grad 2 or Grade 1, in sheet form.
  - 1. Minimum Service Temperature: -40 degrees F.
  - 2. Maximum Service Temperature: 220 degrees F.
  - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

## 2.06 JACKETS

- A. PVC Plastic:
  - 1. Manufacturers:
    - a. Johns Manville Corporation: www.jm.com.
    - b. Substitutions: See Gilbane Project Manual.
  - 2. Jacket: Sheet material, off-white color.
    - a. Minimum Service Temperature: -40 degrees F.
    - b. Maximum Service Temperature: 150 degrees F.
    - c. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
    - d. Thickness: 10 mil.

- e. Connections: Brush on welding adhesive or Pressure sensitive color matching vinyl tape.
- 3. Covering Adhesive Mastic:
  - a. Compatible with insulation.
- B. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
  - 1. Lagging Adhesive:
    - a. Compatible with insulation.

# PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that equipment has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

## 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Factory Insulated Equipment: Do not insulate.
- C. Exposed Equipment: Locate insulation and cover seams in least visible locations.
- D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
- E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.
- F. Insulated equipment containing fluids below ambient temperature: Insulate entire system.
- G. Fiber glass insulated equipment containing fluids below ambient temperature: Provide vapor barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapor barrier adhesive.
- H. For hot equipment containing fluids 140 degrees F or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
- I. For hot equipment containing fluids over 140 degrees F, insulate flanges and unions with removable sections and jackets.
- J. Fiber glass insulated equipment containing fluids above ambient temperature: Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
- K. Inserts and Shields:
  - 1. Application: Equipment 1-1/2 inches diameter or larger.
  - 2. Shields: Galvanized steel or Steel between hangers and inserts.
  - 3. Insert location: Between support shield and equipment and under the finish jacket.
  - 4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
  - 5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- L. Finish insulation at supports, protrusions, and interruptions.
- M. Cover glass fiber insulation with metal mesh and finish with heavy coat of insulating cement.
- N. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
- O. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

#### 3.03 SCHEDULES

- A. Equipment: Domestic hot-water storage tanks, heat exchangers, and expansion tanks, not factory insulated.
  - 1. Operating Temperature: 55 to 140 degrees F.
  - 2. Insulation Material: Glass Fiber
  - 3. Insulation Thickness: 2 inch.
  - 4. Field-Applied Jacket: PVC
  - 5. Vapor Retarder Required: No
  - 6. Finish: None.
# SECTION 22 07 19 PLUMBING PIPING INSULATION

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Piping insulation.
- B. Jackets and accessories.

## 1.02 RELATED REQUIREMENTS

- A. Section 07 84 00 Firestopping.
- B. Section 22 10 05 Plumbing Piping: Placement of hangers and hanger inserts.

## 1.03 REFERENCE STANDARDS

- A. ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
- B. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- C. ASTM B209M Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].
- D. ASTM C177 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- E. ASTM C195 Standard Specification for Mineral Fiber Thermal Insulating Cement.
- F. ASTM C449 Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
- G. ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- H. ASTM C534/C534M Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- I. ASTM C547 Standard Specification for Mineral Fiber Pipe Insulation.
- J. ASTM C552 Standard Specification for Cellular Glass Thermal Insulation.
- K. ASTM C578 Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
- L. ASTM C585 Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
- M. ASTM C591 Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
- N. ASTM C795 Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- O. ASTM D1056 Standard Specification for Flexible Cellular Materials--Sponge or Expanded Rubber.
- P. ASTM D2842 Standard Test Method for Water Absorption of Rigid Cellular Plastics.
- Q. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.
- R. ASTM E96/E96M Standard Test Methods for Water Vapor Transmission of Materials.
- S. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association.
- T. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials.

### 1.04 SUBMITTALS

- A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- B. Samples: Submit two samples of any representative size illustrating each insulation type.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

#### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum 3 years of experience, or and approved by manufacturer.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

#### 1.07 FIELD CONDITIONS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

#### PART 2 PRODUCTS

### 2.01 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION

A. Surface Burning Characteristics: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.

#### 2.02 GLASS FIBER

- A. Manufacturers:
  - 1. Knauf Insulation: www.knaufusa.com.
  - 2. Johns Manville Corporation: www.jm.com.
  - 3. Owens Corning Corp: www.owenscorning.com.
  - 4. CertainTeed Corporation; : www.certainteed.com.
  - 5. Substitutions: See Gilbane Project Manual.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
  - 1. 'K' value: ASTM C177, 0.24 at 75 degrees F.
  - 2. Maximum service temperature: 850 degrees F; 1200 degrees F; 1600 degrees F.
  - 3. Maximum moisture absorption: 0.2 percent by volume.
- C. Insulation: ASTM C547 ; semi-rigid, noncombustible, end grain adhered to jacket.
  - 1. 'K' value: ASTM C177, 0.24 at 75 degrees F.
  - 2. Maximum service temperature: 650 degrees F.
  - 3. Maximum moisture absorption: 0.2 percent by volume.
- D. Vapor Barrier Jacket: White Kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
- E. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- F. Vapor Barrier Lap Adhesive:
  - 1. Compatible with insulation.
- G. Insulating Cement/Mastic:
  - 1. ASTM C195; hydraulic setting on mineral wool.

- H. Fibrous Glass Fabric:
  - 1. Cloth: Untreated; 9 oz/sq yd weight.
  - 2. Blanket: 1.0 lb/cu ft density.
  - 3. Weave: 5x5; 10x10; or 10x20.
- I. Indoor Vapor Barrier Finish:
  - 1. Cloth: Untreated; 9 oz/sq yd weight.
  - 2. Vinyl emulsion type acrylic, compatible with insulation, black or white color.
- J. Outdoor Vapor Barrier Mastic:
  - 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- K. Outdoor Breather Mastic:
  - 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- L. Insulating Cement:
  - 1. ASTM C449/C449M.

## 2.03 CELLULAR GLASS

- A. Manufacturers:
  - 1. Pittsburgh Corning Corporation: www.foamglasinsulation.com.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Insulation: ASTM C552, Grade 1.
  - 1. 'K' value: 0.37 at 100 degrees F.
  - 2. Service Temperature: Up to 900 degrees F.
  - 3. Water Vapor Permeability: 0.005 perm inch.
  - 4. Water Absorption: 0.2 percent by volume, maximum.

## 2.04 EXPANDED POLYSTYRENE

- A. Manufacturers:
- B. Insulation: ASTM C578; rigid closed cell.
  - 1. 'K' value: 0.23 at 75 degrees F.
  - 2. Maximum service temperature: 165 degrees F.
  - 3. Maximum water vapor permeance: 5.0 perms

#### 2.05 EXPANDED PERLITE

- A. Manufacturers:
  - 1. Schundler Company: www.schundler.com.
- B. Insulation: ASTM C610, molded.
  - 1. Maximum service temperature: 1200 degrees F.
  - 2. Maximum water vapor transmission: 0.1 perm.

#### 2.06 POLYISOCYANURATE CELLULAR PLASTIC

- A. Insulation Material: ASTM C591, rigid molded modified polyisocyanurate cellular plastic.
  - 1. Dimension: Comply with requirements of ASTM C585.
  - 2. 'K' value: 0.18 at 75 degrees F, when tested in accordance with ASTM C518.
  - 3. Minimum Service Temperature: -70 degrees F.
  - 4. Maximum Service Temperature: 300 degrees F.
  - 5. Water Absorption: 0.5 percent by volume, maximum, when tested in accordance with ASTM D2842..
  - 6. Moisture Vapor Transmission: 4.0 perm in.
  - 7. Connection: Waterproof vapor barrier adhesive.

## 2.07 POLYETHYLENE

- A. Manufacturers:
  - 1. Armacell International: www.armacell.com.
- B. Insulation: Flexible closed-cell polyethylene tubing, slit lengthwise for installation, complying with applicable requirements of ASTM D1056.
  - 1. 'K' value: ASTM C177; 0.25 at 75 degrees F.
  - 2. Maximum Service Temperature: 200 degrees F.
  - 3. Density: 2 lb/cu ft.
  - 4. Maximum Moisture Absorption: 1.0 percent by volume.
  - 5. Moisture Vapor Permeability: 0.05 perm inch, when tested in accordance with ASTM E96/E96M.
  - 6. Connection: Contact adhesive.

## 2.08 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Manufacturer:
  - 1. Armacell International: www.armacell.com.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C 534 Grade 3;grade 2; grade 1 use molded tubular material wherever possible.
  - 1. Minimum Service Temperature: -40 degrees F.
  - 2. Maximum Service Temperature: 220 degrees F.
  - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

## 2.09 JACKETS

- A. PVC Plastic.
  - 1. Manufacturers:
    - a. Johns Manville Corporation: www.jm.com.
    - b. Substitutions: See Section 01 60 00 Product Requirements.
  - 2. Jacket: One piece molded type fitting covers and sheet material, off-white color.
    - a. Minimum Service Temperature: 0 degrees F.
    - b. Maximum Service Temperature: 150 degrees F.
    - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
    - d. Thickness: 20 mil; 30 mil.
    - e. Connections: Brush on welding adhesive, tacks, pressure sensitive color matching vinyl tape.
  - 3. Covering Adhesive Mastic:
- B. ABS Plastic:

1.

- Jacket: One piece molded type fitting covers and sheet material, off-white color.
- a. Minimum Service Temperature: -40 degrees F.
- b. Maximum Service Temperature of 180 degrees F.
- c. Moisture Vapor Permeability: 0.012 perm inch, when tested in accordance with ASTM E96/E96M.
- d. Thickness: 30 mil.
- e. Connections: Brush on welding adhesive.
- C. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
  - 1. Lagging Adhesive:
    - a. Compatible with insulation.

- D. Aluminum Jacket: ASTM B209 (ASTM B209M) formed aluminum sheet.
  - 1. Thickness: 0.016 inch, 0.020 inch sheet.
  - 2. Finish: Smooth, embossed.
  - 3. Joining: Longitudinal slip joints and 2 inch laps.
  - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
  - 5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
  - 6. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.
- E. Stainless Steel Jacket: ASTM A 666, Type 304 or 316 stainless steel.
  - 1. Thickness: 0.010 inch.
  - 2. Finish: Smooth.
  - 3. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

## 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.
- D. Insulated pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- E. Glass fiber insulated pipes conveying fluids below ambient temperature:
  - 1. Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
  - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- G. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- H. Glass fiber insulated pipes conveying fluids above ambient temperature:
  - 1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
  - 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.
- I. Inserts and Shields:
  - 1. Application: Piping 1-1/2 inches diameter or larger.
  - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
  - 3. Insert location: Between support shield and piping and under the finish jacket.
  - 4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
  - 5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

- J. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 07 84 00.
- K. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.
- L. Buried Piping: Provide factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with one mil thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.
- M. Heat Traced Piping: 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. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

## 3.03 SCHEDULES

### 3.04 INTERIOR INSULATION APPLICATION SCHEDULE

- A. Service: Domestic hot, recirculated hot water.
  - 1. Operating Temperature: 60 to 140 deg F.
  - 2. Insulation Material: Flexible elastomeric or glass fiber.
  - 3. Insulation Thickness: Apply the following insulation thicknesses: a. Pipe, All Sizes: 1.0 inch.
  - 4. Jacket:
    - a. Exposed Spaces (mechanical rooms, closets, etc.) = PVC
    - b. Concealed Spaces = None
  - 5. Vapor Retarder Required: No.
  - 6. Finish: None.
- B. Service: Domestic cold water.
  - 1. Operating Temperature: 35 to 60 deg F.
  - 2. Insulation Material: Flexible elastomeric or glass fiber.
  - 3. Insulation Thickness: Apply the following insulation thicknesses:
    - a. Pipe, 1" or less: 0.5 inch.
    - b. Pipe, 1<sup>1</sup>/<sub>4</sub>" to 2" : 0.5 inch.
    - c. Pipe, 2-1/2" to 4": 1.0 inch.
    - d. Pipe, 5" and up : 1.0 inch.
  - 4. Jacket:
    - a. Exposed Spaces (mechanical rooms, closets, etc.) = PVC
    - b. Concealed Spaces = None
  - 5. Vapor Retarder Required: Yes.
  - 6. Finish: None.
- C. Service: Rainwater conductors.
  - 1. Operating Temperature: 32 to 100 deg F.
  - 2. Insulation Material: Mineral fiber.
  - 3. Insulation Thickness: Apply the following insulation thicknesses:
  - a. Pipe, 3" and up: 1.0 inch.
  - 4. Jacket:
    - a. Concealed Piping None
    - b. Exposed Piping PVC
  - 5. Vapor Retarder Required: Yes.
  - 6. Finish: None.

- D. Service: Roof drain bodies.
  - 1. Operating Temperature: 32 to 100 deg F.
  - 2. Insulation Material: Mineral fiber.
  - 3. Insulation Thickness: 1.0 inch.
  - 4. Jacket:
    - a. Concealed None
    - b. Exposed PVC
  - 5. Vapor Retarder Required: Yes.
  - 6. Finish: None
- E. Service: Sanitary waste piping where heat tracing is installed.
  - 1. Operating Temperature: 35 to 100 deg F.
  - 2. Insulation Material: Mineral fiber.
  - Insulation Thickness: Apply the following insulation thicknesses:
    a. Pipe, 3" and up: 1.0 inch.
  - 4. Jacket: Aluminum.
  - 5. Vapor Retarder Required: Yes.
  - 6. Finish: None.
- F. Service: Condensate drain piping.
  - 1. Operating Temperature: 35 to 75 deg F.
  - 2. Insulation Material: Flexible elastomeric.
  - 3. Insulation Thickness: 0.5 inch.
  - 4. Jacket: None.
  - 5. Vapor Retarder Required: Yes.
  - 6. Finish: None.
- G. Service: Exposed sanitary drains and domestic water supplies and stops for fixtures for the disabled.
  - 1. Operating Temperature: 35 to 120 deg F.
  - 2. Insulation Material: Molded closed cell vinyl.
  - 3. Insulation Thickness: 3/16 inch.
  - 4. Vapor Retarder Required: No.
  - 5. Finish: None.

## 3.05 EXTERIOR INSULATION APPLICATION SCHEDULE

- A. This application schedule is for aboveground insulation outside the building. Loose-fill insulation, for belowground piping, is specified in Division 2 piping distribution Sections.
- B. Service: Domestic water.
  - 1. Operating Temperature: 60 to 180 deg F.
  - 2. Insulation Material: Cellular glass, with jacket
  - 3. Insulation Thickness: Apply the following insulation thicknesses:
    - a. Pipe, 1" or less: 2.0 inch.
    - b. Pipe, 1-1/4" and larger: 2.0 inch.
  - 4. Jacket: Aluminum.
  - 5. Vapor Retarder Required: No.
  - 6. Finish: None.
- C. Service: Storm water.
  - 1. Operating Temperature: 32 to 100 deg F.
  - 2. Insulation Material: Flexible elastomeric.
  - 3. Insulation Thickness: Apply the following insulation thicknesses:
    - a. Pipe, 1-1/4" to 2": 0.5 inch.
    - b. Pipe, 2-1/2" and up: 1.0 inch.

- Field-Applied Jacket: Aluminum. 4.
- Vapor Retarder Required: Yes.
  Finish: None.

## **END OF SECTION**

# SECTION 22 10 05 PLUMBING PIPING

### PART 1 GENERAL

### 1.01 SECTION INCLUDES

- A. Pipe, pipe fittings, valves, and connections for piping systems.
  - 1. Sanitary sewer.
  - 2. Chemical resistant sewer.
  - 3. Acid Waste (Chemical Resistant).
  - 4. Domestic water.
  - 5. Storm water.
  - 6. Gas.
  - 7. Flanges, unions, and couplings.
  - 8. Pipe hangers and supports.
  - 9. Valves.
  - 10. Flow controls.
  - 11. Check.
  - 12. Water pressure reducing valves.
  - 13. Relief valves.
  - 14. Strainers.

## 1.02 RELATED REQUIREMENTS

- A. Section 31 23 16 Excavation.
- B. Section 31 23 23 Fill.
- C. Section 31 23 16.13 Trenching.
- D. Section 33 13 00 Disinfecting of Water Utility Distribution.
- E. Section 07 84 00 Firestopping.
- F. Section 08 31 00 Access Doors and Panels.
- G. Section 09 90 00 Painting and Coating.
- H. Section 22 05 16 Expansion Fittings and Loops for Plumbing Piping.
- I. Section 22 05 53 Identification for Plumbing Piping and Equipment.
- J. Section 22 07 19 Plumbing Piping Insulation.
- K. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.
- L. Section 33 13 00 Disinfecting of Water Utility Distribution.

#### 1.03 REFERENCE STANDARDS

- A. ANSI Z21.22 American National Standard for Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems.
- B. ASME B16.1 Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- C. ASME B16.3 Malleable Iron Threaded Fittings: Classes 150 and 300.
- D. ASME B16.4 Gray Iron Threaded Fittings: Classes 125 and 250.
- E. ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings.
- F. ASME B16.22 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- G. ASME B16.23 Cast Copper Alloy Solder Joint Drainage Fittings DWV.
- H. ASME B16.26 Cast Copper Alloy Fittings for Flared Copper Tubes.

- I. ASME B16.29 Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings DWV.
- J. ASME B31.1 Power Piping.
- K. ASME B31.2 Fuel Gas Piping; The American Society of Mechanical Engineers.
- L. ASME B31.9 Building Services Piping.
- M. ASME BPVC-IV Boiler and Pressure Vessel Code, Section IV Rules for Construction of Heating Boilers.
- N. ASME BPVC-IX Boiler and Pressure Vessel Code, Section IX Welding, Brazing, and Fusing Qualifications.
- O. ASTM A47/A47M Standard Specification for Ferritic Malleable Iron Castings.
- P. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- Q. ASTM A74 Standard Specification for Cast Iron Soil Pipe and Fittings.
- R. ASTM A234/A234M Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- S. ASTM B32 Standard Specification for Solder Metal.
- T. ASTM B42 Standard Specification for Seamless Copper Pipe, Standard Sizes.
- U. ASTM B43 Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
- V. ASTM B68/B68M Standard Specification for Seamless Copper Tube, Bright Annealed.
- W. ASTM B68M Standard Specification for Seamless Copper Tube, Bright Annealed (Metric).
- X. ASTM B75/B75M Standard Specification for Seamless Copper Tube.
- Y. ASTM B75M Standard Specification for Seamless Copper Tube (Metric).
- Z. ASTM B88 Standard Specification for Seamless Copper Water Tube.
- AA. ASTM B88M Standard Specification for Seamless Copper Water Tube (Metric).
- AB. ASTM B280 Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- AC. ASTM B302 Standard Specification for Threadless Copper Pipe, Standard Sizes.
- AD. ASTM B306 Standard Specification for Copper Drainage Tube (DWV).
- AE. ASTM C4 Standard Specification for Clay Drain Tile and Perforated Clay Drain Tile.
- AF. ASTM C14 Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
- AG. ASTM C14M Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe (Metric).
- AH. ASTM C76 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- AI. ASTM C76M Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric).
- AJ. ASTM C425 Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
- AK. ASTM C443 Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
- AL. ASTM C443M Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric).

- AM. ASTM C564 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
- AN. ASTM C700 Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
- AO. ASTM C1053 Standard Specification for Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications.
- AP. ASTM D1785 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- AQ. ASTM D2235 Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
- AR. ASTM D2239 Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
- AS. ASTM D2241 Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
- AT. ASTM D2447 Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter; 2003.
- AU. ASTM D2466 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- AV. ASTM D2513 Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings.
- AW. ASTM D2564 Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
- AX. ASTM D2609 Standard Specification for Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe.
- AY. ASTM D2661 Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings.
- AZ. ASTM D2665 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
- BA. ASTM D2680 Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.
- BB. ASTM D2683 Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
- BC. ASTM D2729 Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- BD. ASTM D2751 Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
- BE. ASTM D2846/D2846M Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems.
- BF. ASTM D2855 Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
- BG. ASTM D2996 Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
- BH. ASTM D2997 Standard Specification for Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
- BI. ASTM D3034 Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

- BJ. ASTM D3262 Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.
- BK. ASTM D3517 Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe.
- BL. ASTM D3754 Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer and Industrial Pressure Pipe.
- BM. ASTM D3840 Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Nonpressure Applications.
- BN. ASTM F437 Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
- BO. ASTM F438 Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
- BP. ASTM F439 Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
- BQ. ASTM F441/F441M Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
- BR. ASTM F442/F442M Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR).
- BS. ASTM F477 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- BT. ASTM F493 Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
- BU. ASTM F628 Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe With a Cellular Core.
- BV. ASTM F679 Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
- BW. ASTM F708 Standard Practice for Design and Installation of Rigid Pipe Hangers.
- BX. ASTM F1281 Standard Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe.
- BY. ASTM F1282 Standard Specification for Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure Pipe.
- BZ. AWS A5.8M/A5.8 Specification for Filler Metals for Brazing and Braze Welding.
- CA. AWWA C105/A21.5 Polyethylene Encasement for Ductile-Iron Pipe Systems.
- CB. AWWA C110/A21.10 Ductile-Iron and Gray-Iron Fittings.
- CC. AWWA C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- CD. AWWA C151/A21.51 Ductile-Iron Pipe, Centrifugally Cast.
- CE. AWWA C651 Disinfecting Water Mains.
- CF. AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution.
- CG. AWWA C901 Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13 mm) Through 3 In. (76 mm), for Water Service.
- CH. AWWA C950 Fiberglass Pressure Pipe.
- CI. CISPI 301 Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications.

- CJ. CISPI 310 Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
- CK. MSS SP-58 Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation.
- CL. MSS SP-67 Butterfly Valves.
- CM. MSS SP-69 Pipe Hangers and Supports Selection and Application; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc..
- CN. MSS SP-70 Cast Iron Gate Valves, Flanged and Threaded Ends.
- CO. MSS SP-71 Cast Iron Swing Check Valves, Flanged and Threaded Ends.
- CP. MSS SP-78 Cast Iron Plug Valves, Flanged and Threaded Ends.
- CQ. MSS SP-80 Bronze Gate, Globe, Angle and Check Valves.
- CR. MSS SP-85 Cast Iron Globe & Angle Valves, Flanged and Threaded Ends.
- CS. MSS SP-89 Pipe Hangers and Supports Fabrication and Installation Practices; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc..
- CT. MSS SP-110 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
- CU. NFPA 54 National Fuel Gas Code; National Fire Protection Association.
- CV. NFPA 58 Liquefied Petroleum Gas Code; National Fire Protection Association.

### 1.04 SUBMITTALS

- A. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- B. Project Record Documents: Record actual locations of valves.

#### 1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with local standards.
  - 1. Maintain one copy on project site.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.
- D. Welder Qualifications: Certified in accordance with ASME (BPV IX).
- E. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

#### 1.06 REGULATORY REQUIREMENTS

- A. Perform Work in accordance with local plumbing code.
- B. Conform to applicable code for installation of backflow prevention devices.
- C. Provide certificate of compliance from authority having jurisdiction indicating approval of installation of backflow prevention devices.

## 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

### 1.08 FIELD CONDITIONS

A. Do not install underground piping when bedding is wet or frozen.

### 1.09 EXTRA MATERIALS

A. Provide two repacking kits for each size valve.

### PART 2 PRODUCTS

### 2.01 SANITARY SEWER PIPING, BURIED BEYOND 5 FEET OF BUILDING

- A. Cast Iron Pipe: ASTM A74 service weight.
  - 1. Fittings: Cast iron.
  - 2. Joint Seals: ASTM C564 neoprene gaskets, or lead and oakum.
- B. PVC Pipe: ASTM D 3034 SDR 35. As permitted by code.
  - 1. Fittings: PVC.
  - 2. Joints: Push-on, using ASTM F477 elastomeric gaskets.
- C. PVC Pipe: ASTM D 2665 or ASTM D 3034. As permitted by code.
  - 1. Fittings: PVC.
  - 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

### 2.02 SANITARY SEWER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Cast Iron Pipe: ASTM A74 service weight.
  - 1. Fittings: Cast iron.
  - 2. Joints: Hub-and-spigot, CISPI HSN compression type with ASTM C564 neoprene gaskets or lead and oakum.
- B. Cast Iron Pipe: CISPI 301, hubless.
  - 1. Fittings: Cast iron.
  - 2. Joints: CISPI 310, neoprene gasket and stainless steel clamp and shield assemblies.

### 2.03 SANITARY SEWER PIPING, ABOVE GRADE

- A. Cast Iron Pipe: ASTM A74, service weight.
  - 1. Fittings: Cast iron.
  - 2. Joint Seals: ASTM C564 neoprene gaskets, or lead and oakum.
- B. Cast Iron Pipe: CISPI 301, hubless, service weight.
  - 1. Fittings: Cast iron.
  - 2. Joints: CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.
- C. PVC Pipe: ASTM D1785 Schedule 40, or ASTM D2241 SDR 26 for not less than 150 psi pressure rating.
  - 1. Fittings: ASTM D2466, PVC.
  - 2. Joints: Solvent welded, with ASTM D2564 Solvent cement.

#### 2.04 CHEMICAL RESISTANT SEWER PIPING

- A. PPFR Pipe: Polypropylene, flame retardant. By Orion/Watts MFG or approved equal.
  - 1. Fittings: Polypropylene, PVDF
  - 2. Joints: Electrical resistance fusion or no-hub coupling

#### 2.05 WATER PIPING, BURIED BEYOND 5 FEET OF BUILDING

- A. Ductile Iron Pipe: AWWA C151/A21.51.
  - 1. Fittings: AWWA C110, ductile or gray iron, standard thickness.
  - 2. Joints: AWWA C111/A21.11, rubber gasket with 3/4 inch diameter rods.
- B. Copper Pipe: ASTM B42, hard drawn.
  - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22 wrought copper and bronze.
  - 2. Joints: ASTM B 32, alloy Sn95 solder.

- C. Copper Pipe: ASTM B42, annealed.
  - 1. Fittings: ASME B16.26, cast bronze.
  - 2. Joints: Flared.

### 2.06 WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Copper Pipe: ASTM B42, hard drawn.
  - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22 wrought copper and bronze.
  - 2. Joints: ASTM B 32, alloy Sn95 solder.
- B. Copper Pipe: ASTM B42, annealed.
  - 1. Fittings: ASME B16.26, cast bronze.
  - 2. Joints: Flared.

### 2.07 WATER PIPING, ABOVE GRADE

- A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), Drawn (H).
  - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
  - 2. Joints: ASTM B32, alloy Sn95 solder.

### 2.08 STORM WATER PIPING, BURIED BEYOND 5 FEET OF BUILDING

- A. Cast Iron Pipe: ASTM A74 service weight.
  - 1. Fittings: Cast iron.
  - 2. Joint Seals: ASTM C564 neoprene gaskets, or lead and oakum.
- B. Concrete Pipe: Nonreinforced, ASTM C14 (ASTM C14M) Class 1.
  - 1. Fittings: Concrete, as specified for pipe.
    - 2. Joints: Elastomeric gaskets; ASTM C443 (ASTM C443M).
- C. PVC Pipe: ASTM D2665 or ASTM D3034.
  - 1. Fittings: PVC.
  - 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

#### 2.09 STORM WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Cast Iron Pipe: ASTM A74 service weight.
  - 1. Fittings: Cast iron.
  - 2. Joint Seals: ASTM C564 neoprene gaskets, or lead and oakum.
- B. Cast Iron Pipe: CISPI 301, hubless, service weight.
  - 1. Fittings: Cast iron.
  - 2. Joints: Neoprene gaskets and stainless steel clamp-and-shield assemblies.

## 2.10 STORM WATER PIPING, ABOVE GRADE

- A. Cast Iron Pipe: ASTM A74 service weight.
  - 1. Fittings: Cast iron.
  - 2. Joint Seals: ASTM C564 neoprene gaskets, or lead and oakum.
- B. Cast Iron Pipe: CISPI 301, hubless, service weight.
  - 1. Fittings: Cast iron.
  - 2. Joints: Neoprene gaskets and stainless steel clamp-and-shield assemblies.
- C. PVC Pipe: ASTM D2665 or ASTM D3034.
  - 1. Fittings: PVC.
  - 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

#### 2.11 NATURAL GAS PIPING, BURIED BEYOND 5 FEET OF BUILDING

- A. Steel Pipe: ASTM A53/A53M Schedule 40 black.
  - 1. Fittings: ASTM A234/A234M, wrought steel welding type, with AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

- 2. Joints: ASME B31.1, welded.
- 3. Jacket: AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

### 2.12 NATURAL GAS PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Steel Pipe: ASTM A53/A53M Schedule 40 black.
  - 1. Fittings: ASTM A234/A234M, wrought steel welding type.
  - 2. Joints: ASME B31.1 or ASME B31.9, welded.
  - 3. Jacket: AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

### 2.13 NATURAL GAS PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M Schedule 40 black.
  - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
  - 2. Joints: NFPA 54, threaded or welded to ASME B31.1 or ASME B31.9.

## 2.14 FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 Inches and Under:
  - 1. Ferrous pipe: Class 150 malleable iron threaded unions.
  - 2. Copper tube and pipe: Class 150 bronze unions with soldered joints.
- B. Flanges for Pipe Size Over 1 Inch:
  - 1. Ferrous pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
  - 2. Copper tube and pipe: Class 150 slip-on bronze flanges; preformed neoprene gaskets.
- C. Grooved and Shouldered Pipe End Couplings:
  - 1. Housing: Malleable iron clamps to engage and lock, designed to permit some angular deflection, contraction, and expansion; steel bolts, nuts, and washers; galvanized for galvanized pipe.
  - 2. Sealing gasket: "C" shape composition sealing gasket.
- D. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

### 2.15 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
  - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
  - 2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
  - 3. Trapeze Hangers: Welded steel channel frames attached to structure.
  - 4. Vertical Pipe Support: Steel riser clamp.
- B. Plumbing Piping Drain, Waste, and Vent:
  - 1. Conform to ASME B31.9.
  - 2. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
  - 3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
  - 4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
  - 5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
  - 6. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
  - 7. Vertical Support: Steel riser clamp.
  - 8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

- 9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- C. Plumbing Piping Water:
  - 1. Conform to ASME B31.9.
  - 2. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
  - 3. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
  - 4. Hangers for Hot Pipe Sizes 2 Inches to 4 Inches: Carbon steel, adjustable, clevis.
  - 5. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron pipe roll, double hanger.
  - 6. Multiple or Trapeze Hangers: Steel channels with welded supports or spacers and hanger rods.
  - 7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded supports or spacers and hanger rods, cast iron roll.
  - 8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
  - 9. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
  - 10. Wall Support for Hot Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron pipe roll.
  - 11. Vertical Support: Steel riser clamp.
  - 12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
  - 13. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, locknut, nipple, floor flange, and concrete pier or steel support.
  - 14. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron pipe roll and stand, steel screws, and concrete pier or steel support.
  - 15. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

## 2.16 GATE VALVES

- A. Manufacturers:
  - 1. Conbraco Industries: www.conbraco.com.
  - 2. Nibco, Inc: www.nibco.com.
  - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Up To and Including 3 Inches:
  - 1. 1, Class 125, bronze body, bronze trim, rising stem, handwheel, inside screw, solid wedge disc, solder ends.
- C. 2 Inches and Larger:
  - 1. 1, Class 125, iron body, bronze trim, outside screw and yoke, handwheel, solid wedge disc, flanged ends. Provide chain-wheel operators for valves 6 inches and larger mounted over 8 feet above floor.

## 2.17 GLOBE VALVES

- A. Manufacturers:
  - 1. Conbraco Industries: www.conbraco.com.
  - 2. Nibco, Inc: www.nibco.com.
  - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Up To and Including 3 Inches:
  - 1. 1, Class 125, bronze body, bronze trim, handwheel, bronze disc, solder ends.
- C. 2 Inches and Larger:
  - 1. 1, Class 125, iron body, bronze trim, handwheel, outside screw and yoke, renewable bronze plug-type disc, renewable seat, flanged ends. Provide chain-wheel operators for valves 6 inches and larger mounted over 8 feet above floor.

### 2.18 BALL VALVES

- A. Manufacturers:
  - 1. Conbraco Industries: www.conbraco.com.
  - 2. Nibco, Inc: www.nibco.com.
  - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Construction, 4 Inches and Smaller: MSS SP-110, Class 150, 400 psi CWP, bronze, two piece body, chrome plated brass ball, regular port, teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, solder ends with union.

#### 2.19 PLUG VALVES

- A. Manufacturers:
  - 1. Conbraco Industries: www.conbraco.com.
  - 2. Nibco, Inc: www.nibco.com.
  - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Construction 2-1/2 Inches and Larger: 1, 175 psi CWP, cast iron body and plug, pressure lubricated, teflon or Buna N packing, flanged or grooved ends. Provide lever operator with set screw.

### 2.20 BUTTERFLY VALVES

- A. Manufacturers:
  - 1. Hammond Valve: www.hammondvalve.com.
  - 2. Crane Co.: www.cranevalve.com.
  - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Construction 1-1/2 Inches and Larger: MSS SP-67, 200 psi CWP, cast or ductile iron body, nickel-plated ductile iron disc, resilient replaceable EPDM, Buna N, or EPT seat, wafer, lug, or grooved ends, extended neck, 10 position lever handle.
- C. Provide gear operators for valves 8 inches and larger, and chain-wheel operators for valves mounted over 8 feet above floor.

## 2.21 FLOW CONTROLS

- A. Manufacturers:
  - 1. ITT Bell & Gossett: www.bellgossett.com.
  - 2. Griswold Controls: www.griswoldcontrols.com.
  - 3. Taco, Inc: www.taco-hvac.com.
- B. Construction: Class 125, Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.
- C. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi psi.

#### 2.22 SWING CHECK VALVES

- A. Manufacturers:
  - 1. Hammond Valve: www.hammondvalve.com.
  - 2. Nibco, Inc: www.nibco.com.
  - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Up to 3 Inches:
  - 1. 1, Class 125, bronze body and cap, bronze swing disc with rubber seat, solder ends.
- C. Over 3 Inches:
  - 1. 1, Class 125, iron body, bronze swing disc, renewable disc seal and seat, flanged or grooved ends.

## 2.23 SPRING LOADED CHECK VALVES

- A. Manufacturers:
  - 1. Hammond Valve: www.hammondvalve.com.
  - 2. Crane Co.: www.cranevalve.com.
  - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Class 125, iron body, bronze trim, stainless steel springs, bronze disc, Buna N seals, wafer style ends.

## 2.24 WATER PRESSURE REDUCING VALVES

- A. Manufacturers:
  - 1. Amtrol Inc: www.amtrol.com.
  - 2. Cla-Val Co: www.cla-val.com.
  - 3. Watts Regulator Company: www.wattsregulator.com.
- B. Up to 2 Inches:
  - 1. MSS SP-80, bronze body, stainless steel and thermoplastic internal parts, fabric reinforced diaphragm, strainer, threaded single or double union ends.
- C. Over 2 Inches:
  - MSS SP-85, cast iron body, bronze fitted, elastomeric diaphragm and seat disc, flanged.

## 2.25 RELIEF VALVES

1

## 2.26 STRAINERS

# 2.27 RELIEF VALVES

- A. Pressure Relief:
  - 1. Manufacturers:
    - a. Cla-Val Co: www.cla-val.com.
    - b. Henry Technologies: www.henrytech.com.
    - c. Watts Regulator Company: www.wattsregulator.com.
  - 2. AGA Z21.22 certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.
- B. Temperature and Pressure Relief:
  - 1. Manufacturers:
    - a. Cla-Val Co: www.cla-val.com.
    - b. Henry Technologies: www.henrytech.com.
    - c. Watts Regulator Company: www.wattsregulator.com.
  - AGA Z21.22 certified, bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, temperature relief maximum 210 degrees F, capacity ASME (BPV IV) certified and labelled.

## 2.28 STRAINERS

- A. Manufacturers:
  - 1. Armstrong International, Inc: www.armstronginternational.com.
  - 2. Green Country Filter Manufacturing: www.greencountryfilter.com.
  - 3. WEAMCO: www.weamco.com.
- B. Size 2 inch and Under:
  - 1. Threaded brass body for 175 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
  - 2. Class 150, threaded bronze body 300 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
- C. Size 1-1/2 inch to 4 inch:

- 1. Class 125, flanged iron body, Y pattern with 1/16 inch stainless steel perforated screen.
- D. Size 5 inch and Larger:
  - 1. Class 125, flanged iron body, basket pattern with 1/8 inch stainless steel perforated screen.

## PART 3 EXECUTION

## 3.01 EXAMINATION

A. Verify that excavations are to required grade, dry, and not over-excavated.

## 3.02 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

### 3.03 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. All gas piping is to be painted standard ANSI yellow.
- C. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- D. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- E. Install piping to maintain headroom, conserve space, and not interfere with use of space.
- F. Group piping whenever practical at common elevations.
- G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 22 05 16.
- H. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 07 19.
- I. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 31 00.
- J. Establish elevations of buried piping outside the building to ensure not less than 3 ft of cover.
- K. Install vent piping penetrating roofed areas to maintain integrity of roof assembly .
- L. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- M. Provide support for utility meters in accordance with requirements of utility companies.
- N. Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting. Refer to Section 09 90 00.
- O. Excavate in accordance with Section 31 23 16.
- P. Backfill in accordance with Section 31 23 23.
- Q. Install bell and spigot pipe with bell end upstream.
- R. Install valves with stems upright or horizontal, not inverted.
- S. Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.
- T. Install water piping to ASME B31.9.
- U. Install fuel oil piping to ASME B31.9.
- V. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- W. Sleeve pipes passing through partitions, walls and floors.

- X. Inserts:
  - 1. Provide inserts for placement in concrete formwork.
  - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
  - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
  - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
  - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.
- Y. Pipe Hangers and Supports:
  - 1. Install in accordance with ASME B31.9.
  - 2. Support horizontal piping as scheduled.
  - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
  - 4. Place hangers within 12 inches of each horizontal elbow.
  - 5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
  - 6. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
  - 7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
  - 8. Provide copper plated hangers and supports for copper piping.
  - 9. Prime coat exposed steel hangers and supports. Refer to Section 09 90 00. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
  - 10. Provide hangers adjacent to motor driven equipment with vibration isolation; refer to Section 22 05 48.
  - 11. Support cast iron drainage piping at every joint.

## 3.04 APPLICATION

- A. Use grooved mechanical couplings and fasteners only in accessible locations.
- B. Install unions downstream of valves and at equipment or apparatus connections.
- C. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- D. Install gate or ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- E. Install globe valves for throttling, bypass, or manual flow control services.
- F. Provide lug end butterfly valves adjacent to equipment when provided to isolate equipment.
- G. Provide spring loaded check valves on discharge of water pumps.
- H. Provide plug valves in natural gas systems for shut-off service.
- I. Provide flow controls in water recirculating systems where indicated.

## 3.05 TOLERANCES

- A. Drainage Piping: Establish invert elevations within 1/2 inch vertically of location indicated and slope to drain at minimum of 1/4 inch per foot slope.
- B. Water Piping: Slope at minimum of 1/32 inch per foot and arrange to drain at low points.

## 3.06 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Disinfect water distribution system in accordance with Section 33 13 00.
- B. Prior to starting work, verify system is complete, flushed and clean.

- C. Ensure Ph of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- D. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
- E. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- F. Maintain disinfectant in system for 24 hours.
- G. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- H. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- I. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

### 3.07 SERVICE CONNECTIONS

- A. Provide new sanitary and storm sewer services. Before commencing work check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.
- B. Provide new water service complete with approved reduced pressure backflow preventer and water meter with by-pass valves, pressure reducing valve.
  - 1. Provide sleeve in wall for service main and support at wall with reinforced concrete bridge. Calk enlarged sleeve and make watertight with pliable material. Anchor service main inside to concrete wall.
  - 2. Provide 18 gage galvanized sheet metal sleeve around service main to 6 inch above floor and 6 feet minimum below grade. Size for minimum of 2 inches of loose batt insulation stuffing.
- C. Provide new gas service complete with gas meter and regulators. Gas service distribution piping to have initial minimum pressure of 7 inch wg. Provide regulators on each line serving gravity type appliances, sized in accordance with equipment.

## 3.08 SCHEDULES

- A. Pipe Hanger Spacing:
  - 1. Metal Piping:
    - a. Pipe size: 1/2 inches to 1-1/4 inches:
      - 1) Maximum hanger spacing: 6.5 ft.
      - 2) Hanger rod diameter: 3/8 inches.
    - b. Pipe size: 1-1/2 inches to 2 inches:
      - 1) Maximum hanger spacing: 10 ft.
      - 2) Hanger rod diameter: 3/8 inch.
    - c. Pipe size: 2-1/2 inches to 3 inches:
      - Maximum hanger spacing: 10 ft.
        Hanger rod diameter: 1/2 inch.
    - d. Pipe size: 4 inches to 6 inches:
      - Maximum hanger spacing: 10 ft.
      - 2) Hanger rod diameter: 5/8 inch.
    - e. Pipe size: 8 inches to 12 inches:
      - 1) Maximum hanger spacing: 14 ft.
      - 2) Hanger rod diameter: 7/8 inch.
    - f. Pipe size: 14 inches and Over:
      - 1) Maximum hanger spacing: 20 ft.
      - 2) Hanger rod diameter: 1 inch.
  - 2. Plastic Piping:

- a. Pipe Size 1" to 6":

  - Maximum hanger spacing: 6 ft.
    Hanger rod diameter: 3/8 inch. 2)
- b. Pipe Size 8" and Over:
  - 1) Maximum hanger spacing: 6 ft.
  - 2) Hanger rod diameter: 7/8 inch.

# **END OF SECTION**

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# SECTION 22 10 06 PLUMBING PIPING SPECIALTIES

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Roof and floor drains.
- B. Cleanouts.
- C. Hydrants.
- D. Backflow preventers.
- E. Water hammer arrestors.
- F. Interceptors.
- G. Thermostatic mixing valves.
- H. Catch basins and manholes.

## 1.02 RELATED REQUIREMENTS

- A. Section 33 05 13 Manholes and Structures.
- B. Section 03 30 00 Cast-in-Place Concrete: Manhole bottoms.
- C. Section 22 10 05 Plumbing Piping.
- D. Section 22 40 00 Plumbing Fixtures.
- E. Section 22 30 00 Plumbing Equipment.
- F. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

# 1.03 REFERENCE STANDARDS

- A. ASME A112.6.3 Floor and Trench Drains.
- B. ASME A112.6.4 Roof, Deck, and Balcony Drains.
- C. ASSE 1011 Hose Connection Vacuum Breakers.
- D. ASSE 1012 Backflow Preventer with Intermediate Atmospheric Vent.
- E. ASSE 1013 Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers.
- F. ASSE 1019 Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance.
- G. ASTM C478 Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
- H. ASTM C478M Standard Specification for Circular Precast Reinforced Concrete Manhole Sections [Metric].
- I. PDI-WH 201 Water Hammer Arresters.

## 1.04 SUBMITTALS

- A. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- B. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.
- C. Certificates: Certify that grease or oil interceptors meet or exceed specified requirements.
- D. Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.
- E. Project Record Documents: Record actual locations of equipment, cleanouts, backflow preventers, water hammer arrestors.

- F. Operation Data: Indicate frequency of treatment required for interceptors.
- G. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

## 1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years documented experience.

### 1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept specialties on site in original factory packaging. Inspect for damage.

### 1.07 EXTRA MATERIALS

- A. Supply for Caesar Rodney School District's use in maintenance of project:
  - 1. Two loose keys for outside hose bibbs.
  - 2. Two hose end vacuum breakers for hose bibbs.

# PART 2 PRODUCTS

## 2.01 DRAINS

- A. Manufacturers:
  - 1. Josam Company: www.josam.com.
  - 2. Jay R. Smith Manufacturing Company: www.jayrsmith.com.
  - 3. Zurn Industries, Inc: www.zurn.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Roof Drains:
  - 1. Assembly: ASME A112.6.4.
  - 2. Body: Lacquered cast iron with sump.
  - 3. Strainer: Removable polyethylene, cast metal, cast bronze, or cast iron dome with vandal proof screws.
  - 4. Accessories: Coordinate with roofing type.
    - a. Membrane flange and membrane clamp with integral gravel stop.
    - b. Adjustable under deck clamp.
    - c. Roof sump receiver.
    - d. Waterproofing flange.
    - e. Controlled flow weir.
    - f. Leveling frame.
    - g. Adjustable extension sleeve for roof insulation.
    - h. Perforated or slotted ballast guard extension for inverted roof.
    - i. Perforated stainless steel ballast guard extension.
- C. Parapet Drains:
  - 1. Lacquered or Galvanized cast iron body with aluminum flashing clamp collar and epoxy coated or nickel bronze sloping grate.
- D. Canopy and Cornice Drains:
  - 1. Lacquered or Galvanized cast iron body with aluminum flashing clamp collar and epoxy coated or nickel bronze flat strainer.
- E. Roof Overflow Drains:
  - 1. Lacquered or Galvanized cast iron body and clamp collar and bottom clamp ring; pipe extended to above flood elevation.
- F. Downspout Nozzles:
  - 1. Bronze round with straight bottom section.
- G. Area Drains:
  - 1. Assembly: ASME A112.6.4.

- 2. Body: Lacquered cast iron with sump.
- 3. Strainer: Round nickel-bronze.
- 4. Accessories: Membrane flange and membrane clamp with integral gravel stop, with adjustable under deck clamp, roof sump receiver, waterproofing flange, levelling frame, adjustable extension sleeve (for insulation), and perforated stainless steel ballast guard extension.
- H. Floor Drain:
  - 1. Round, type 304 stainless steel adjustable floor drain with anchor flange and medium-duty vertically adjustable satin finish top.

## 2.02 CLEANOUTS

- A. Manufacturers:
  - 1. Jay R. Smith Manufacturing Company: www.jayrsmith.com.
  - 2. Josam Company: www.josam.com.
  - 3. Zurn Industries, Inc: www.zurn.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Cleanouts at Exterior Surfaced Areas:
  - 1. Round cast nickel bronze access frame and non-skid cover.
- C. Cleanouts at Exterior Unsurfaced Areas:
  - 1. Line type with lacquered cast iron body and round epoxy coated gasketed cover.
- D. Cleanouts at Interior Finished Floor Areas:
  - 1. Lacquered cast iron body with anchor flange, reversible clamping collar, threaded top assembly, and round gasketed scored cover in service areas and round gasketed depressed cover to accept floor finish in finished floor areas.
- E. Cleanouts at Interior Finished Wall Areas:
  - 1. Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with machine screw.
- F. Cleanouts at Interior Unfinished Accessible Areas: Calked or threaded type. Provide bolted stack cleanouts on vertical rainwater leaders.

#### 2.03 HYDRANTS

- A. Manufacturers:
  - 1. Arrowhead Brass Company: www.arrowheadbrass.com.
  - 2. Jay R. Smith Manufacturing Company: www.jayrsmith.com.
  - 3. Zurn Industries, Inc: www.zurn.com.
- B. Wall Hydrants: Exterior
  - 1. ASSE 1019; tamper-proof, freeze resistant, self-draining type with chrome plated wall plate hose thread spout, handwheel, and integral vacuum breaker.
- C. Roof Hydrant:
  - 1. Freezeless, cast iron support components. Drain connection, EPDM Boot.

## 2.04 BACKFLOW PREVENTERS

- A. Manufacturers:
  - 1. Conbraco Industries: www.conbraco.com.
  - 2. Watts Regulator Company: www.wattsregulator.com.
  - 3. Zurn Industries, Inc: www.zurn.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Reduced Pressure Backflow Preventers:
  - 1. ASSE 1013; bronze body with bronze internal parts and stainless steel springs; two independently operating, spring loaded check valves; diaphragm type differential pressure

relief valve located between check valves; third check valve that opens under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.

### 2.05 DOUBLE CHECK VALVE ASSEMBLIES

- A. Manufacturers:
  - 1. Conbraco Industries: www.conbraco.com.
  - 2. Watts Regulator Company: www.wattsregulator.com.
  - 3. Zurn Industries, Inc: www.zurn.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Double Check Valve Assemblies:
  - 1. ASSE 1012; Bronze body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent.

### 2.06 WATER HAMMER ARRESTORS

- A. Manufacturers:
  - 1. Jay R. Smith Manufacturing Company: www.jayrsmith.com.
  - 2. Watts Regulator Company: www.wattsregulator.com.
  - 3. Zurn Industries, Inc: www.zurn.com.
  - 4. Souix Chief Company.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
- B. Water Hammer Arrestors:
  - Stainless steel construction, bellows or piston type sized in accordance with PDI-WH 201, precharged suitable for operation in temperature range -100 to 300 degrees F and maximum 250 psi working pressure.

#### 2.07 MIXING VALVES

- A. Thermostatic Mixing Valves:
  - 1. Manufacturers:
    - a. ESBE: www.esbe.se/en.
    - b. Leonard Valve Company: www.leonardvalve.com.
    - c. Honeywell Water Controls: http://yourhome.honeywell.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
  - 2. Valve: Chrome plated cast brass body, stainless steel or copper alloy bellows, integral temperature adjustment.
  - 3. Accessories:
    - a. Check valve on inlets.
    - b. Volume control shut-off valve on outlet.
    - c. Stem thermometer on outlet.
    - d. Strainer stop checks on inlets.
  - 4. Cabinet: 16 gage prime coated steel, for recessed mounting with keyed lock.

# PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
- C. Encase exterior cleanouts in concrete flush with grade.
- D. Install floor cleanouts at elevation to accommodate finished floor.

- E. Install approved portable water protection devices on plumbing lines where contamination of domestic water may occur; on boiler feed water lines, janitor rooms, fire sprinkler systems, premise isolation, irrigation systems, flush valves, interior and exterior hose bibbs.
- F. Pipe relief from backflow preventer to nearest drain.
- G. Install water hammer arrestors complete with accessible isolation valve on hot and cold water supply piping to lavatories, sinks, washing machines, toilets, urinal and any other quick closing valves .

## END OF SECTION

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# SECTION 22 30 00 PLUMBING EQUIPMENT

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Water heaters.
- B. Expansion Tanks.
- C. Pumps.
  - 1. Circulators.
  - 2. Sump / Sewage Pumps.
- D. Water pressure booster system.

## 1.02 RELATED REQUIREMENTS

A. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

## 1.03 REFERENCE STANDARDS

- A. ANSI Z21.10.1 Gas Water Heaters Volume I Storage Water Heaters with Input Ratings of 75,000 Btu per Hour or Less.
- B. ANSI Z21.10.3 Gas-Fired Water Heaters Volume III Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating and Instantaneous.
- C. ASME BPVC-VIII-1 Boiler and Pressure Vessel Code, Section VIII, Division 1 Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers.

## 1.04 SUBMITTALS

- A. Product Data:
  - 1. Provide dimension drawings of water heaters indicating components and connections to other equipment and piping.
  - 2. Indicate pump type, capacity, power requirements.
  - 3. Provide certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
  - 4. Provide electrical characteristics and connection requirements.
- B. Shop Drawings:
  - 1. Indicate heat exchanger dimensions, size of tappings, and performance data.
  - 2. Indicate dimensions of tanks, tank lining methods, anchors, attachments, lifting points, tappings, and drains.
- C. Manufacturer's Instructions .
- D. Project Record Documents: Record actual locations of components .
- E. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- F. Warranty: Submit manufacturer warranty and ensure forms have been completed in Caesar Rodney School District's name and registered with manufacturer.

## 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of experience.
- B. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

C. Performance: Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.

### **1.06 CERTIFICATIONS**

- A. Water Heaters: NSF approved.
- B. Gas Water Heaters: Certified by CSA International to 1 or 2, as applicable, in addition to requirements specified elsewhere.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

### 1.07 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

### 1.08 WARRANTY

A. Provide five year manufacturer warranty for domestic water heaters and in-line circulator.

### **1.09 EXTRA MATERIALS**

A. Provide two pump seals.

### PART 2 PRODUCTS

### 2.01 COMMERCIAL GAS FIRED WATER HEATERS

- A. Type: Automatic, tankless natural gas-fired.
- B. Manufacturers:
  - 1. IntelliHot
    - 2. Noritz
    - 3. Rinnai
    - 4. Substitutions: See Section 01 60 00 Product Requirements.
- C. Performance: See plans.
- D. Accessories: Provide:
  - 1. Venting Kit.
  - 2. Isolation Valves
- E. Certification: As water heater by ASME, rated for output temperatures of 100 to 180 degrees F.
- F. Controls: Digital controls for output temperature management (default setting at 120 degrees), safety controls for flame failure, boiling protection, combustion fan failure, over-current, and gas valve failure.

#### 2.02 DIAPHRAGM-TYPE EXPANSION TANKS

- A. Manufacturers:
  - 1. Amtrol Inc: www.amtrol.com.
  - 2. ITT Bell & Gossett: www.bellgossett.com.
  - 3. Taco, Inc: www.taco-hvac.com.
- B. Construction: Welded steel, tested and stamped in accordance with ASME (BPV VIII, 1); supplied with National Board Form U-1, rated for working pressure of 125 psig, with flexible diaphragm sealed into tank, and steel legs or saddles.
- C. Accessories: Pressure gage and air-charging fitting, tank drain; precharge to 55 psig.

## 2.03 IN-LINE CIRCULATOR PUMPS

A. Manufacturers:

- 1. Armstrong Pumps Inc: www.armstrongpumps.com.
- 2. ITT Bell & Gossett: www.bellgossett.com.
- 3. SIHI Group: www.sterlingsihi.com.
- 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Casing: Bronze, rated for 125 psig working pressure.
- C. Impeller: Bronze.
- D. Shaft: Alloy steel with integral thrust collar and two oil lubricated bronze sleeve bearings.
- E. Seal: Carbon rotating against a stationary ceramic seat.
- F. Drive: Flexible coupling.

## 2.04 PRESSURE BOOSTER SYSTEMS

- A. Manufacturers: See Schedule
- B. System: Packaged with two pumps, factory assembled, tested, and adjusted; shipped to site as integral unit; consisting of pumps, valves, and piping, with control panel assembled on fabricated steel base with structural steel framework.
- C. Structural Elements: The entire system shall be factory skid mounted on a minimum; 304 stainless-steel structural square tube support frame, with in-shear molded rubber vibration isolators. Horizontal systems shall feature a rack-style servicing system which will allow the user access to the pump and motor while the pump can remains on the system skid. (see plans for details)
- D. Valves: All valves shall be full port bronze ball valves, with S.S. ball and stem design for valve sizes 2 1/2" and smaller, and cast iron, epoxy coated lever operated, grooved end type butterfly valves, with stainless steel disc, and Stainless Steel shaft, for valve sizes 3" and larger. Valves must be rated for maximum pressure service for the system and also comply with NSF 61 Drinking Water requirements.
- E. Control Panel: The pumping system control panel shall incorporate the following elements, and criteria:
  - 1. The pump controller, and all its components shall be housed in a NEMA 3R, UL listed, ventilated control enclosure. The controller shall have a main power disconnect switch, with enclosure door interlock, which shall require opening the disconnect switch before the control cabinet may be opened. The system shall provide for a single point electrical connection, with all power, both primary, and secondary to be de-activated with opening the main disconnect switch.
  - 2. The entire controller shall be UL 508A listed, INDUSTRIAL CONTROL PANELS, and have all UL listed devices of Touch Safe design, which shall eliminate any bare handed shock hazard. All primary and secondary power circuits shall be protected through the use of Touch Safe panel design.
  - 3. All secondary control circuit wiring shall be 24 volts, AC/DC, or less, to include all pilot lights, selector switches, panel meters, HMI, PLC and alarm devices. The Primary motor branch circuits shall have thermal magnetic circuit breaker protection, (fuses shall not be acceptable). There shall be no part of the interior of the control enclosure, which shall produce a bare handed shock hazard even with the controller powered up. There shall be no exceptions to this requirement.
  - 4. The controller shall utilize a programmable 24 volt EEPROM control module, which shall provide all pump staging, and timing functions. Low Suction and High System alarm conditions shall have audible and visual indicators, with timed delayed proof of condition and automatic reset. The EEPROM Module shall provide for automatic alternation between equal pumps. Pressure-based pump sequencing is unacceptable since a change in suction pressure can skew the lag sequencing point. Pump sequencing must be accomplished through electronic means allowing for the lag pump to carry the load prior to

the lead handing off. Control system will guarantee PSI deviation of no more than +/- 1PSI on pump time-out alternation. Pump alternation shall enunciate on the main screen. There shall be no failure of any one system component which will render the system incapable of maintaining system flow to the building. All controls must be 100% fail-safe including failure of the PLC.

- 5. The controller panel shall have the following features:
  - a. NEMA 4, 256 color, 6" Touch Screen interface shall provide access to all timing, control and informational feedback on all system operations. This HMI shall provide for re-calibration of the system and all system parameters without the need to open the control panel door.
  - b. Touch screen shall include panel screen access to a logged alarm function with time and date stamp.
  - c. Touch screen shall incorporate a key logger able to save the last 400 button pushes in a non-volatile PLC memory.
  - d. Touch screen shall incorporate a PSI trending chart with the ability to export information including VFD speed, system PSI, KW, run times in an exportable CSV format on an externally removable USB flash drive.
  - e. All pump functions shall be accessible including Run Hours, Amperage, PSI and system temperature and remaining time until shutdown.
  - f. System shall provide for an optional BACNet communications including the ability to monitor and control the system remotely.
  - g. Provide three phase lightning protection for entire control panel.
  - h. Main power un-fused, door interlocked disconnect switch.
  - i. Individual, glycerin filled, panel mounted, stainless steel suction and system pressure gauges.
  - j. Low Suction Condition, and High System Pressure alarms, both audible, and visual
  - k. Automatic pump alternation between equal split pumps.
  - I. Low suction condition shall be initiated via a separate dedicated pressure switch(for pressure feed systems), or a liquid level float switch, (for break tank operation).
  - m. All control components shall be UL Listed, or recognized devices.
  - n. The controller shall be UL 508 Listed, and in accordance with the National Electrical Code, (NEC).
- 6. All components shall be of standard manufacture, and not be of proprietary sole source. Manufacturer will have these spare parts available either through local product representation or directly from the manufacturer via Next Day shipping.
- F. Pump Sequencing: All pump sequencing shall be initiated and controlled via the PLC. Upon pressure drop, the Lead pump shall initiate and run to attempt to satisfy demand. An empty pipe condition is to be determined by an algorithm allowing for a slow ramp to set point to prevent system pressure shocks. In the event the pressure set point is not satisfied or the pump is being overloaded, an additional pump shall immediately initiate to assist the lead pump in meeting demand. After the pressure set point is reached, the pumps shall continue to meet demand, if demand decreases, a sensor less means of control shall immediately shut down the pump to prevent no flow conditions and to prevent short cycling of the pumps. These algorithms take into account system pressure and system demand, the system shall revert to the stand-by mode (no flow shutdown) when no flow is present. A continuously monitored motor FLA algorithm shall prevent any motor from overloading and initialize additional pumps to share system demand. The system shall employ algorithms to detect pipe break and stop system. initiate an alarm and log the event. In the event of a sensor loss, the system shall run one pump in a semi-automatic mode allowing the building to maintain a minimum pressure until the sensor can be repaired or replaced. An automated PID algorithm shall continuously monitor system pressure and auto-tune the PID based on demand allowing for fast system demand response while maintaining smooth steady state pressure. The PID algorithms shall incorporate intelligent

algorithms to start the pumps at the point of creating pressure saving energy and reducing time to set pressure upon pump call. The software will also contain GreenFlo<sup>™</sup>, an algorithm to allow the system to fully comply with the newly adopted requirements of ANSI/ASHRAE/IES, Standard 90.1 - 2010; also referred to as the "Energy Standard for Buildings".

- G. The system shall not require external flow meters or KW monitoring. The system will not implement speed, thermal or time delay means to detect and shut down pumps on a no demand condition as this wastes energy and provides for unnecessary run times.
- H. Bladder Tank: No bladder tank is recommended, or required for this type system as there is no pressure change at the discharge of the pump. Since there is no pressure change, a tank is un-usable in a variable speed booster application.
- I. Pressure Regulation: Pressure regulation is provided via the variable frequency drive controllers, with PID control. No other pressure regulators are required. In the event of any drive failure, next drive in sequence shall start automatically and the failed drive shall indicate a fault condition. In the event of a loss of transducer signal, the system shall be pre-programmed to a fail-safe mode which will ramp pumps to a safe-speed and maintain positive pressure on the system piping without shutting the system down. All system and drive settings shall be re-settable from the HMI (touch screen) including PID values without the need to open the controller door.
- J. Fabrication:
  - 1. All headers, nipples, and welded attachments to the headers shall be type 304 stainless steel materials.
  - 2. All welding shall be in accordance with section IX of the ASME Boiler and Pressure Vessel code, and shall be performed by welders qualified under that standard
  - 3. The completed system shall be hydrostatically and performance tested to simulated jobsite conditions and pre-set for plug and play operation. Copies of these test reports shall be provided in the O&M Manuals which will be turned over to the owner. These manuals shall included all settings, explanation of these operations and final test reports from the factory test.
  - 4. Each pump shall have an individual resilient seated non-slam type check valve on each pump immediately downstream of the pump discharge.
  - 5. All pumps shall be mounted utilizing in-shear rubber vibration isolators mounted to the motor bases
  - 6. All stainless steel surfaces shall feature a consistent brushed metal finish so that all exposed stainless surfaces are identical in material finish.
- K. Start-up:
  - 1. Initial factory start-up, and owner training shall be performed by a qualified factory trained technician. A factory certified start-up report must be provide to the owner, dated and signed by the factory technician.
- L. Parts: A complete listing of all components in the manufacture of the equipment shall be provide in the O&M including individual factory part numbers for each component in the packaged equipment.
- M. Owner Training: The owner instruction, and training shall include, but not be limited to the following:
  - 1. Training in the replacement of the motor, mechanical seals and pump impeller.
  - 2. Safe replacement of electrical components.
  - 3. Proper operation of the system, troubleshooting, alarm, and reset features
- N. On-Site Factory Warranty: Provide a 2-year Factory sponsored extended warranties for all equipment servicing common areas. Warranty shall include both parts and labor in the event of a failure of any equipment in accordance with factory warranty certificate. Warranty repairs

must be performed by the manufacturer or a properly trained factory authorized service representative.

## 2.05 SUMP PUMPS

- A. Manufacturers:
  - 1. ITT Bell & Gossett.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Type: Vertical centrifugal, direct connected, duplex arrangement.
- C. Casing: Cast iron volute with radial clearance around impeller .
- D. Impeller: Cast iron; enclosed or semi-open non-clog, keyed to stainless steel shaft.
- E. Support: Cast iron pedestal motor support on steel floor plate with gas tight gaskets.
- F. Bearings: Forced grease lubricated bronze sleeve spaced maximum 48 inches and grease lubricated ball thrust at floor plate.
- G. Drive: Flexible coupling to vertical, solid shaft ball bearing electric motor.
- H. Sump: Fiberglass with lockable painted aluminum inspection cover and alarm fittings.
- I. Controls (Duplex): Float operated mechanical alternator with float rod, stops, and corrosion resistant float to alternate operation of pumps, cut-in second pump on rising level or lead pump failure, separate pressure switch high level alarm with transformer, alarm bell, and standpipe, and emergency float switch with float rod, stops, and corrosion resistant float to operate both pumps on failure of alternator.

## PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install plumbing equipment in accordance with manufacturer's instructions, as required by code, and complying with conditions of certification, if any.
- B. Coordinate with plumbing piping and related gas venting and electrical work to achieve operating system.
- C. Pumps:
  - 1. Provide air cock and drain connection on horizontal pump casings.
  - 2. Provide line sized isolating valve and strainer on suction and line sized soft seated check valve and balancing valve on discharge.
  - 3. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. Provide supports under elbows on pump suction and discharge line sizes 4 inches and over.
  - 4. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
  - 5. Align and verify alignment of base mounted pumps prior to start-up.

# END OF SECTION
# SECTION 22 40 00 PLUMBING FIXTURES

### PART 1 GENERAL

# 1.01 SECTION INCLUDES

- A. Water closets.
- B. Lavatories.
- C. Sinks.
- D. Service sinks.
- E. Drinking fountains.

# 1.02 RELATED REQUIREMENTS

- A. Section 07 90 05 Joint Sealers: Seal fixtures to walls and floors.
- B. Section 22 10 05 Plumbing Piping.
- C. Section 22 10 06 Plumbing Piping Specialties.
- D. Section 22 30 00 Plumbing Equipment.
- E. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

# 1.03 REFERENCE STANDARDS

- A. ANSI Z124.1 American National Standard for Plastic Bathtub Units; 1995.
- B. ANSI Z124.2 American National Standard for Plastic Shower Units; 1995.
- C. ANSI Z124.1.2 American National Standard for Plastic Bathtub and Shower Units.
- D. ANSI Z358.1 American National Standard for Emergency Eyewash and Shower Equipment.
- E. ARI 1010 Self-Contained, Mechanically-Refrigerated Drinking-Water Coolers; Air-Conditioning and Refrigeration Institute.
- F. ASME A112.6.1M Supports for Off-the-Floor Plumbing Fixtures for Public Use.
- G. ASME A112.18.1 Plumbing Supply Fittings.
- H. ASME A112.19.1M Enameled Cast Iron Plumbing Fixtures; The American Society of Mechanical Engineers.
- I. ASME A112.19.2 Ceramic Plumbing Fixtures.
- J. ASME A112.19.3 Stainless Steel Plumbing Fixtures (Designed for Residential Use).
- K. ASME A112.19.4M Porcelain Enameled Formed Steel Plumbing Fixtures.
- L. ASME A112.19.5 Flush Valves and Spuds for Water Closets, Urinals, and Tanks.
- M. ASME A112.19.14 Six Liter Water Closets Equipped with Dual Flushing Device.

### 1.04 SUBMITTALS

- A. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- B. Samples: Submit two sets of color chips for each standard color.
- C. Manufacturer's Instructions: Indicate installation methods and procedures.
- D. Maintenance Data: Include fixture trim exploded view and replacement parts lists.
- E. Waterless Urinals: Submit recommended frequency of maintenance and parts replacement, methods of cleaning, sources of replacement supplies and parts.
- F. Warranty: Submit manufacturer warranty and ensure forms have been completed in Caesar Rodney School District's name and registered with manufacturer.

### 1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of experience.

### 1.06 REGULATORY REQUIREMENTS

A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

### 1.07 MOCK-UP

- A. Provide mock-up of typical bathroom group.
- B. Mock-up may remain as part of the Work.

### 1.08 DELIVERY, STORAGE, AND HANDLING

- A. Accept fixtures on site in factory packaging. Inspect for damage.
- B. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

### 1.09 WARRANTY

A. Provide five year manufacturer warranty for electric water cooler.

### **1.10 EXTRA MATERIALS**

A. Supply two sets of faucet washers, flush valve service kits, and lavatory supply fittings.

### PART 2 PRODUCTS

#### 2.01 FLUSH VALVE WATER CLOSETS

- A. Water Closets: Vitreous china, ASME A112.19.2, wall hung, siphon jet flush action, china bolt caps.
  - 1. Flush Volume: 1.28 gallon, maximum.
  - 2. Flush Valve: Exposed (top spud).
  - 3. Flush Operation: Manual, oscillating handle.
  - 4. Handle Height: 44 inches or less.
  - 5. Manufacturers:
    - a. American Standard Inc: www.americanstandard.com.
    - b. Kohler.
    - c. Toto USA: www.totousa.com.
    - d. Zurn Industries, Inc: www.zurn.com.
    - e. Substitutions: See Section 01 60 00 Product Requirements.
- B. Flush Valves: ASME A112.18.1, diaphragm type, complete with vacuum breaker stops and accessories.
  - 1. Exposed Type: Chrome plated, escutcheon, integral screwdriver stop.
  - 2. Manufacturers:
    - a. Toto USA: www.totousa.com
    - b. Sloan Valve Company: www.sloanvalve.com.
    - c. Zurn Industries, Inc: www.zurn.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
- C. Seats:
  - 1. Manufacturers:
    - a. Kohler
    - b. Bemis Manufacturing Company: www.bemismfg.com.
    - c. Church Seat Company: www.churchseats.com.

- d. Olsonite: www.olsonite.com.
- e. Substitutions: See Section 01 60 00 Product Requirements.
- 2. Solid plastic, open front, extended back, brass bolts, with cover.
- D. Water Closet Carriers:
  - Manufacturers:
  - a. JR Smith.
  - b. Sloan Valve Company: www.sloanvalve.com.
  - c. Zurn Industries, Inc: www.zurn.com.
  - d. Substitutions: See Section 01 60 00 Product Requirements.
  - 2. ASME A112.6.1M; adjustable cast iron frame, integral drain hub and vent, adjustable spud, lugs for floor and wall attachment, threaded fixture studs with nuts and washers.

### 2.02 LAVATORIES

1.

- A. Lavatory Manufacturers:
  - 1. American Standard Inc
  - 2. Eljer
  - 3. Kohler Company: www.kohler.com.
  - 4. Zurn Industries, Inc: www.zurn.com.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
- B. Supply Faucet: ASME A112.18.1; chrome plated combination supply fitting with pop-up waste, water economy aerator with maximum flow of 0.5 gallon per minute (low-flow), indexed handles.
- C. Accessories:
  - 1. Chrome plated 17 gage brass P-trap with clean-out plug and arm with escutcheon.
  - 2. Offset waste with perforated open strainer.
  - 3. Screwdriver stops.
  - 4. Rigid supplies.

#### 2.03 WATER FOUNTAINS

- A. Electric Water Cooler Manufacturers:
  - 1. Tri Palm International/Oasis: www.tripalmint.com.
  - 2. Elkay Manufacturing Company: www.elkay.com.
  - 3. Haws Corporation: www.hawsco.com.
- B. Fountain:
  - 1. A surface handicapped-height, fully ADA compliant mounted water fountain with stainless steel top, stainless steel; stainless steel body, elevated anti-squirt bubbler with stream guard, automatic stream regulator, push button, bottle filling station, and mounting bracket.

### 2.04 SERVICE SINKS

- A. Service Sink Manufacturers:
  - 1. Kohler
  - 2. Elkay Manufacturing Company: www.elkay.com.
- B. Bowl:
  - 1. White floor mounted, with one inch wide shoulders. Vinyl bumper guard stainless steel strainer.
- C. Trim:
  - 1. ASME A112.18.1 exposed wall type supply with cross handles, spout wall brace, vacuum breaker, hose end spout, strainers, eccentric adjustable inlets, integral screwdriver stops with covering caps and adjustable threaded wall flanges.
- D. Accessories:

- 1. 5 feet of 1/2 inch diameter plain end reinforced plastic or rubber hose.
- 2. Hose clamp hanger.
- 3. Mop hanger.

# PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B. Verify that electric power is available and of the correct characteristics.
- C. Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks.

### 3.02 PREPARATION

A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

# 3.03 INSTALLATION

- A. Install each fixture with trap, easily removable for servicing and cleaning.
- B. Provide chrome plated rigid or flexible supplies to fixtures with screwdriver stops, reducers, and escutcheons.
- C. Install components level and plumb.
- D. Install and secure fixtures in place with wall supports or wall carriers and bolts.
- E. Seal fixtures to wall and floor surfaces with sealant as specified in Section 07 90 05, color to match fixture.
- F. Solidly attach water closets to floor with lag screws. Lead flashing is not intended hold fixture in place.

# 3.04 INTERFACE WITH WORK OF OTHER SECTIONS

A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

### 3.05 ADJUSTING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

# 3.06 CLEANING

A. Clean plumbing fixtures and equipment.

# END OF SECTION

### SECTION 23 05 13

### MOTOR REQUIREMENTS FOR HVAC AND PLUMBING EQUIP

### PART 1 GENERAL

### 1.01 SECTION INCLUDES

- A. Single phase electric motors.
- B. Three phase electric motors.

### 1.02 RELATED REQUIREMENTS

- A. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.
- B. Section 26 29 13 Enclosed Controllers.

### 1.03 REFERENCE STANDARDS

- A. ABMA STD 9 Load Ratings and Fatigue Life for Ball Bearings.
- B. IEEE 112 IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
- C. NEMA MG 1 Motors and Generators.
- D. NFPA 70 National Electrical Code.
- E. National Grid "Motor-Up" Rebate Program/Initiative.

### 1.04 SUBMITTALS

- A. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- B. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 1/2 horsepower.
- C. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.
- D. Operation Data: Include instructions for safe operating procedures.
- E. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

#### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacture of electric motors for HVAC use, and their accessories, with minimum three years documented product development, testing, and manufacturing experience.
- B. Conform to applicable electrical code, NFPA 70 and local energy code.
- C. Provide certificate of compliance from authority having jurisdiction indicating approval of high efficiency motors.
- D. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc. or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

#### 1.07 WARRANTY

A. Provide five year manufacturer warranty for motors larger than 20 horsepower.

# PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. Baldor Electric Company/ABB Group: www.baldor.com.
- B. Lincoln Motors: www.lincolnmotors.com.
- C. A. O. Smith Electrical Products Company: www.aosmithmotors.com.
- D. Reliance Electric/Rockwell Automation: www.reliance.com.

### 2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Electrical Service: Refer to Section 26 27 17 for required electrical characteristics.
- B. Electrical Service, General. See drawings for specific details:
  - 1. Motors 1/2 HP and Smaller: 115 volts, single phase, 60 Hz
  - 2. Motors Larger than 1/2 Horsepower: 460 volts, three phase, 60 Hz.
- C. Construction:
  - 1. Open drip-proof type except where specifically noted otherwise.
  - 2. Design for continuous operation in 40 degrees C environment.
  - 3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
  - 4. Motors with frame sizes 254T and larger: Premium Efficiency Type.
- D. Explosion-Proof Motors: UL approved and labelled for hazard classification, with over temperature protection.
- E. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor.
- F. Wiring Terminations:
  - 1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
  - 2. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

### 2.03 APPLICATIONS

- A. Exception: Motors less than 250 watts, for intermittent service may be the equipment manufacturer's standard and need not conform to these specifications.
- B. Single phase motors for shaft mounted fans and centrifugal pumps: Split phase type.
- C. Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type or electronically commutated (ECM) type. See schedules for requirements.
- D. Single phase motors for fans, pumps, and blowers: Capacitor start type.
- E. Single phase motors for fans, blowers, and pumps: Capacitor start, capacitor run type.
- F. Motors located in outdoors and in draw through cooling towers: Totally enclosed weatherproof epoxy-treated type.

### 2.04 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- A. Starting Torque: Less than 150 percent of full load torque.
- B. Starting Current: Up to seven times full load current.
- C. Breakdown Torque: Approximately 200 percent of full load torque.
- D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.

E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

### 2.05 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- A. Starting Torque: Exceeding one fourth of full load torque.
- B. Starting Current: Up to six times full load current.
- C. Multiple Speed: Through tapped windings.
- D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

### 2.06 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque.
- B. Starting Current: Less than five times full load current.
- C. Pull-up Torque: Up to 350 percent of full load torque.
- D. Breakdown Torque: Approximately 250 percent of full load torque.
- E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.
- G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

### 2.07 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Starting Torque: Between 1 and 1-1/2 times full load torque.
- B. Starting Current: Six times full load current.
- C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
- E. Insulation System: NEMA Class B or better.
- F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 26 29 13.
- I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- J. Sound Power Levels: To NEMA MG 1.
- K. Part Winding Start Above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.

- L. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
- M. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.
- N. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

# PART 3 EXECUTION

# 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C. Check line voltage and phase and ensure agreement with nameplate.
- D. Provide detailed installation and purchase information for reimbursement by Utility for rebate program.

# 3.02 SCHEDULE - PREMIUM EFFICIENCY

- A. NEMA Open Motor Service Factors.
  - 1. 1/6-1/3 hp:
    - a. 3600 rpm: 1.35.
    - b. 1800 rpm: 1.35.
    - c. 1200 rpm: 1.35.
    - d. 900 rpm: 1.35.
  - 2. 1/2 hp:
    - a. 3600 rpm: 1.25.
    - b. 1800 rpm: 1.25.
    - c. 1200 rpm: 1.25.
    - d. 900 rpm: 1.15.
  - 3. 3/4 hp:
    - a. 3600 rpm: 1.25.
    - b. 1800 rpm: 1.25.
    - c. 1200 rpm: 1.15.
    - d. 900 rpm: 1.15.
  - 4. 1 hp:
    - a. 3600 rpm: 1.25.
    - b. 1800 rpm: 1.15.
    - c. 1200 rpm: 1.15.
    - d. 900 rpm: 1.15.
  - 5. 1.5-150 hp:
    - a. 3600 rpm: 1.15.
    - b. 1800 rpm: 1.15.
    - c. 1200 rpm: 1.15.
    - d. 900 rpm: 1.15.
- B. Three Phase Premium Efficiency, Open Drip-Proof Performance:
  - 1. Ratings.
    - a. 1 hp:
      - 1) NEMA Frame: 145T.
      - 2) Minimum Percent Power Factor: 72.
      - Minimum Percent Efficiency: 82.5% @ 1200 RPM, 85.5%@ 1800 RPM, 77% @ 3600 RPM

- b. 1-1/2 hp:
  - 1) NEMA Frame: 182T.
  - 2) Minimum Percent Power Factor: 73.
  - Minimum Percent Efficiency: 86.5% @ 1200 RPM, 86.5% @ 1800 RPM, 84%
    @ 3600 RPM
- c. 2 hp:
  - 1) NEMA Frame: 184T.
  - 2) Minimum Percent Power Factor: 75.
  - Minimum Percent Efficiency: 87.5% @ 1200 RPM, 86.5% @ 1800 RPM, 85.5%
    @ 3600 RPM
- d. 3 hp:
  - 1) NEMA Frame: 213T.
  - 2) Minimum Percent Power Factor: 60.
  - Minimum Percent Efficiency: 88.5% @ 1200 RPM, 89.5% @ 1800 RPM, 85.5%
    @ 3600 RPM
- e. 5 hp:
  - 1) NEMA Frame: 215T.
  - 2) Minimum Percent Power Factor: 65.
  - Minimum Percent Efficiency: 89.5% @ 1200 RPM, 89.5% @ 1800 RPM, 86.5%
    @ 3600 RPM
- f. 7-1/2 hp:
  - 1) NEMA Frame: 254T.
  - 2) Minimum Percent Power Factor: 73.
  - Minimum Percent Efficiency: 90.2% @ 1200 RPM, 91% @ 1800 RPM, 88.5%
    @ 3600 RPM
- g. 10 hp:
  - 1) NEMA Frame: 256T.
  - 2) Minimum Percent Power Factor: 74.
  - Minimum Percent Efficiency: 91.7% @ 1200 RPM, 91.7% @ 1800 RPM, 89.5%
    @ 3600 RPM
- h. 15 hp:
  - 1) NEMA Frame: 284T.
  - 2) Minimum Percent Power Factor: 77.
  - Minimum Percent Efficiency: 91.7% @ 1200 RPM, 93% @ 1800 RPM, 90.2%
    @ 3600 RPM.
- i. 20 hp:
  - 1) NEMA Frame: 286T.
  - 2) Minimum Percent Power Factor: 78.
  - Minimum Percent Efficiency: 92.4% @ 1200 RPM, 93% @ 1800 RPM, 91% @ 3600 RPM
- j. 25 hp:
  - 1) NEMA Frame: 324T.
  - 2) Minimum Percent Power Factor: 74.
  - Minimum Percent Efficiency: 93% @ 1200 RPM, 93.6% @ 1800 RPM, 91.7%
    @ 3600 RPM
- k. 30 hp:
  - 1) NEMA Frame: 326T.
  - 2) Minimum Percent Power Factor: 78.
  - Minimum Percent Efficiency: 93.6% @ 1200 RPM, 94.1% @ 1800 RPM, 91.7%
    @ 3600 RPM
- I. 40 hp:

- 1) NEMA Frame: 364T.
- 2) Minimum Percent Power Factor: 77.
- 3) Minimum Percent Efficiency: 94.1% @ 1200 RPM, 94.1 @ 1800 RPM, 92.4% @ 3600 RPM
- m. 50 hp:
  - 1) NEMA Frame: 365T.
  - 2) Minimum Percent Power Factor: 79.
  - Minimum Percent Efficiency: 94.1% @ 1200 RPM, 94.5% @ 1800 RPM, 93%
    @ 3600 RPM
- n. 60 hp:
  - 1) NEMA Frame: 404T.
  - 2) Minimum Percent Power Factor: 82.
  - 3) Minimum Percent Efficiency: 93.
- o. 75 hp:
  - 1) NEMA Frame: 405T.
  - 2) Minimum Percent Power Factor: 80.
  - 3) Minimum Percent Efficiency: 93.
- p. 100 hp:
  - 1) NEMA Frame: 444T.
  - 2) Minimum Percent Power Factor: 80.
  - 3) Minimum Percent Efficiency: 93.
- C. Three Phase Premuim Efficiency, Totally Enclosed, Fan Cooled Performance:
  - 1200 rpm.

1.

- a. 1 hp:
  - 1) NEMA Frame: 145T.
  - 2) Minimum Percent Power Factor: 72.
  - Minimum Percent Efficiency: 82.5% @ 1200 RPM, 85.5% 2 1800 RPM, 77% @ 3600 RPM
- b. 1-1/2 hp:
  - 1) NEMA Frame: 182T.
  - 2) Minimum Percent Power Factor: 73.
  - Minimum Percent Efficiency: 87.5% @ 1200 RPM, 86.5% @ 1800 RPM, 84%
    @ 3600 RPM
- c. 2 hp:
  - 1) NEMA Frame: 184T.
  - 2) Minimum Percent Power Factor: 68.
  - Minimum Percent Efficiency: 88.5% @ 1200 RPM, 86.5% @ 1800 RPM, 85.5%
    @ 3600 RPM
- d. 3 hp:
  - 1) NEMA Frame: 213T.
  - 2) Minimum Percent Power Factor: 63.
  - Minimum Percent Efficiency: 89.5% @ 1200 RPM, 89.5% @ 1800 RPM, 86.5%
    @ 3600 RPM
- e. 5 hp:
  - 1) NEMA Frame: 215T.
  - 2) Minimum Percent Power Factor: 66.
  - Minimum Percent Efficiency: 89.5% @ 1200 RPM, 89.5% @ 1800 RPM, 88.5%
    @ 3600 RPM
- f. 7-1/2 hp:
  - 1) NEMA Frame: 254T.
  - 2) Minimum Percent Power Factor: 68.

- Minimum Percent Efficiency: 91% @ 1200 RPM, 91.7% @ 1800 RPM, 89.5%
  @ 3600 RPM
- g. 10 hp:
  - 1) NEMA Frame: 256T.
  - 2) Minimum Percent Power Factor: 75.
  - 3) Minimum Percent Efficiency: 91% @ 1200 RPM, 91.7% @ 1800 RPM, 90.2% @ 3600 RPM
- h. 15 hp:
  - 1) NEMA Frame: 284T.
  - 2) Minimum Percent Power Factor: 72.
  - Minimum Percent Efficiency: 91.7% @ 1200 RPM, 92.4% @ 1800 RPM, 91%
    @ 3600 RPM
- i. 20 hp:
  - 1) NEMA Frame: 286T.
  - 2) Minimum Percent Power Factor: 76.
  - 3) Minimum Percent Efficiency: 91.7% @ 1200 RPM, 93% @ 1800 RPM, 91% @ 3600 RPM
- j. 25 hp:
  - 1) NEMA Frame: 324T.
  - 2) Minimum Percent Power Factor: 71.
  - Minimum Percent Efficiency: 93% @ 1200 RPM, 93.6% @ 1800 RPM, 91.7%
    @ 3600 RPM
- k. 30 hp:
  - 1) NEMA Frame: 326T.
  - 2) Minimum Percent Power Factor: 79.
  - Minimum Percent Efficiency: 93% @ 1200 RPM, 93.6% @ 1800 RPM, 91.7% @ 3600 RPM.
- l. 40 hp:
  - 1) NEMA Frame: 364T.
  - 2) Minimum Percent Power Factor: 78.
  - Minimum Percent Efficiency: 94.1% @ 1200 RPM, 94.1% @ 1800 RPM, 92.4%
    @ 3600 RPM
- m. 50 hp:
  - 1) NEMA Frame: 365T.
  - 2) Minimum Percent Power Factor: 81.
  - 3) Minimum Percent Efficiency: 94.1% @ 1200 RPM, 94.5% @ 1800 RPM, 93% @ 3600 RPM
- n. Over 50 HP Refer to National Grid "Motor Up" Energy Efficiency requirements for reimbursement.

### END OF SECTION

THIS PAGE MILINION MILLING MAIL

# SECTION 23 05 48 VIBRATION AND SEISMIC CON. FOR EQUIPMENT

### PART 1 GENERAL

### 1.01 SECTION INCLUDES

- A. Equipment support bases.
- B. Roof curbs.
- C. Inertia bases.
- D. Vibration isolators.
- E. Seismic restraints.

### 1.02 RELATED REQUIREMENTS

A. Section 03 30 00 - Cast-in-Place Concrete.

### 1.03 SUBMITTALS

- A. Product Data: Provide schedule of vibration isolator type with location and load on each.
- B. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each. Indicate seismic control measures.
- C. Manufacturer's Instructions: Indicate installation instructions with special procedures and setting dimensions.

### PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. Isolation Technology, Inc: www.isolationtech.com.
- B. Kinetics Noise Control, Inc: www.kineticsnoise.com.
- C. Mason Industries: www.mason-ind.com.

### 2.02 PERFORMANCE REQUIREMENTS

- A. General:
  - 1. All vibration isolators, base frames and inertia bases to conform to all uniform deflection and stability requirements under all operating loads.
  - 2. Steel springs to function without undue stress or overloading.
  - 3. Steel springs to operate in the linear portion of the load versus deflection curve over deflection range of not less than 50 percent above specified deflection.
  - 4. Lateral to vertical stiffness ratio to not exceed 0.08 with spring deflection at minimum 75 percent of specified deflection.
  - 5. All equipment mounted on vibration isolated bases to have minimum operating clearance of 2 inches between the base and floor or support beneath unless noted otherwise.

### 2.03 EQUIPMENT SUPPORT BASES

- A. Structural Bases:
  - 1. Construction: Engineered, structural steel frames with welded brackets for side mounting of the isolators.
  - 2. Frames: Square, rectangular or T-shaped.
  - 3. Design: Sufficiently rigid to prevent misalignment or undue stress on machine, and to transmit design loads to isolators and snubbers.
- B. Concrete Inertia Bases:
  - 1. Construction: Engineered, steel forms, with integrated isolator brackets and anchor bolts, welded or tied reinforcing bars running both ways in a single layer.
  - 2. Size: 6 inches minimum depth and sized to accommodate elbow supports.

- 3. Mass: Minimum of 1.5 times weight of isolated equipment.
- 4. Connecting Point: Reinforced to connect isolators and snubbers to base including template and fastening devices for equipment.
- 5. Concrete: Filled on site with minimum 3000 psi concrete. See Section 03 30 00 for additional requirements.

#### 2.04 ROOF CURBS

- A. Vibration Isolation Curbs:
  - 1. Non-Seismic Curb Rail:
    - a. Location: Between existing roof curb and rooftop equipment.
    - b. Construction: Aluminum.
    - c. Integral vibration isolation to conform to requirements of this section.
    - d. Weather exposed components consist of corrosion resistant materials.
  - 2. Non-Seismic Curb:
    - a. Location: Between structure and rooftop equipment.
    - b. Construction: Aluminum.
    - c. Integral vibration isolation to conform to requirements of this section.
    - d. Weather exposed components consist of corrosion resistant materials.
  - 3. Seismic Curb:
    - a. Location: Between structure and rooftop equipment.
    - b. Construction: Steel.
    - c. Integral vibration isolation to conform to requirements of this section.
    - d. Snubbers consist of minimum 0.25 inch thick resilient pads to avoid metal-to-metal contact without compromising vibration isolating capabilities.
    - e. Weather exposed components consist of corrosion resistant materials.

### 2.05 INERTIA BASES

- A. Concrete Inertia Bases:
  - 1. Construction: Structural steel channel perimeter frame, with gusseted brackets and anchor bolts, reinforcing; concrete filled.
  - 2. Mass: Minimum of 1.5 times weight of isolated equipment.
  - 3. Connecting Point: Reinforced to connect isolators and snubbers to base.
  - 4. Concrete: Minimum 3000 psi concrete.

### 2.06 VIBRATION ISOLATORS

- A. Open Spring Isolators:
  - 1. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 2. Spring Mounts: Provide with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.
  - 3. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.
  - 4. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- B. Restrained Open Spring Isolators:
  - 1. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 2. Spring Mounts: Provide with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.

- 3. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.
- 4. Restraint: Provide heavy mounting frame and limit stops.
- 5. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- C. Closed Spring Isolators:
  - 1. Type : Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.
  - 2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 3. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators, and neoprene side stabilizers with minimum 0.25 inch clearance.
  - 4. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- D. Restrained Closed Spring Isolators:
  - 1. Type : Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.
  - 2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 3. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators, and neoprene side stabilizers with minimum 0.25 inch clearance and limit stops.
  - 4. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- E. Spring Hangers:
  - 1. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
  - 2. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators.
  - 3. Misalignment: Capable of 20 degree hanger rod misalignment.
  - 4. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- F. Neoprene Pad Isolators:
  - 1. Rubber or neoprene waffle pads.
    - a. Hardness: 30 durometer.
    - b. Thickness: Minimum 1/2 inch.
    - c. Maximum Loading: 50 psi.
    - d. Rib Height: Maximum 0.7 times width.
  - 2. Configuration: Single layer.
  - 3. Configuration: 1/2 inch thick waffle pads bonded each side of 1/4 inch thick steel plate.
- G. Rubber Mount or Hanger: Molded rubber designed for 0.4 inch deflection with threaded insert.
- H. Glass Fiber Pads: Neoprene jacketed pre-compressed molded glass fiber.
- I. Seismic Snubbers:
  - 1. Type: Non-directional and double acting unit consisting of interlocking steel members restrained by neoprene elements.
  - 2. Elements: Replaceable neoprene, minimum of 0.75 inch thick with minimum 1/8 inch air gap.
  - 3. Capacity: 4 times load assigned to mount groupings at 0.4 inch deflection.

- 4. Attachment Points and Fasteners: Capable of withstanding 3 times rated load capacity of seismic snubber.
- J. Roof Mounting Curb: 14 inches high with rigid steel lower section containing adjustable spring pockets with restrained spring isolators, steel upper section to support rooftop equipment, and continuous elastomeric membrane extending from upper section for counterflashing over roofing. Provide acoustical package consisting of interior perimeter angles and cross members to support up to two layers of gypsum board.

### PART 3 EXECUTION

### 3.01 INSTALLATION - GENERAL

- A. Install in accordance with manufacturer's instructions.
- B. Bases:
  - 1. Set steel bases for one inch clearance between housekeeping pad and base.
  - 2. Set concrete inertia bases for 2 inches clearance between housekeeping pad and base.
  - 3. Adjust equipment level.
- C. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.
- D. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.
- E. Provide pairs of horizontal limit springs on fans with more than 6.0 inches WC static pressure, and on hanger supported, horizontally mounted axial fans.
- F. Provide seismic snubbers for all equipment, piping, and ductwork mounted on isolators. Each inertia base shall have minimum of four seismic snubbers located close to isolators. Snub equipment designated for post-disaster use to 0.05 inch maximum clearance. Other snubbers shall have clearance between 0.15 inch and 0.25 inch.
- G. Support piping connections to equipment mounted on isolators using isolators or resilient hangers as follows:
  - 1. Up to 4 Inches Pipe Size: First three points of support.
  - 2. 5 to 8 Inches Pipe Size: First four points of support.
  - 3. 10 inches Pipe Size and Over: First six points of support.
  - 4. Select three hangers closest to vibration source for minimum 1.0 inch static deflection or static deflection of isolated equipment. Select remaining isolators for minimum 1.0 inch static deflection or 1/2 static deflection of isolated equipment.

#### 3.02 FIELD QUALITY CONTROL

A. Inspect isolated equipment after installation and submit report. Include static deflections.

#### 3.03 SCHEDULE

- A. Pipe Isolation Schedule.
  - 1. 1 Inch Pipe Size: Isolate 120 diameters from equipment.
  - 2. 2 Inch Pipe Size: Isolate 90 diameters from equipment.
  - 3. 3 Inch Pipe Size: Isolate 80 diameters from equipment.
  - 4. 4 Inch Pipe Size: Isolate 75 diameters from equipment.
  - 5. 6 Inch Pipe Size: Isolate 60 diameters from equipment.
  - 6. 8 Inch Pipe Size: Isolate 60 diameters from equipment.
  - 7. 10 Inch Pipe Size: Isolate 54 diameters from equipment.
  - 8. 12 Inch Pipe Size: Isolate 50 diameters from equipment.
  - 9. 16 Inch Pipe Size: Isolate 45 diameters from equipment.
  - 10. 24 Inch Pipe Size: Isolate 38 diameters from equipment.

- 11. Over 24 Inch Pipe Size: As indicated.
- B. Equipment Isolation Schedule.
  - 1. Pumps.

**END OF SECTION** 

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# SECTION 23 05 53 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

# PART 1 GENERAL

# 1.01 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Stencils.
- D. Pipe Markers.
- E. Ceiling tacks.

# 1.02 RELATED REQUIREMENTS

A. Section 09 90 00 - Painting and Coating: Identification painting.

# 1.03 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems.

# 1.04 SUBMITTALS

- A. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- B. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C. Product Data: Provide manufacturers catalog literature for each product required.
- D. Samples: Submit two labels or tags 1/2 x 4 inch in size.
- E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- F. Project Record Documents: Record actual locations of tagged valves.

### PART 2 PRODUCTS

### 2.01 IDENTIFICATION APPLICATIONS

- A. Air Handling Units: Nameplates.
- B. Air Terminal Units: Tags.
- C. Automatic Controls: Tags. Key to control schematic.
- D. Control Panels: Nameplates.
- E. Dampers: Ceiling tacks, where located above lay-in ceiling.
- F. Heat Transfer Equipment: Nameplates.
- G. Instrumentation: Tags.
- H. Major Control Components: Nameplates.
- I. Piping: Tags.
- J. Pumps: Nameplates.
- K. Relays: Tags.
- L. Small-sized Equipment: Tags.
- M. Tanks: Nameplates.
- N. Thermostats: Nameplates.
- O. Valves: Tags and ceiling tacks where located above lay-in ceiling.
- P. Water Treatment Devices: Nameplates.

### 2.02 MANUFACTURERS

- A. Brady Corporation: www.bradycorp.com.
- B. Champion America, Inc: www.Champion-America.com.
- C. Seton Identification Products: www.seton.com/aec.

#### 2.03 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved letters.
  - 1. Letter Color: White.
  - 2. Letter Height: 1/2 inch.
  - 3. Background Color: Black.

### 2.04 TAGS

- A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- B. Metal Tags: Aluminum with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- C. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

### 2.05 STENCILS

- A. Stencils: With clean cut symbols and letters of following size:
  - 1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
  - 2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
  - 3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
  - 4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
  - 5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
  - 6. Ductwork and Equipment: 2-1/2 inch high letters.
- B. Stencil Paint: As specified in Section 09 90 00, semi-gloss enamel, colors conforming to ASME A13.1.

### 2.06 PIPE MARKERS

- A. Color: Conform to ASME A13.1.
- B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.
- E. Refrigerant piping is to be labeled such that refrigerant state (high pressure gas, low pressure gas, or liquid) is listed in addition to the connected fan coil tag and associated room tag.
- F. Color code as follows:
  - 1. Coordinate with owner.

### 2.07 CEILING TACKS

A. Description: Steel with 3/4 inch diameter color coded head.

- B. Color code as follows:
  - 1. HVAC Equipment: Yellow.
  - 2. Fire Dampers and Smoke Dampers: Red.
  - 3. Heating/Cooling Valves: Blue.
  - 4. Verify ceiling tack colors with owner.

### PART 3 EXECUTION

### 3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 09 90 00 for stencil painting.

### 3.02 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Verify identification colors and designations with owner prior to application.
- C. Install tags with corrosion resistant chain.
- D. Apply stencil painting in accordance with Section 09 90 00.
- E. Install plastic pipe markers in accordance with manufacturer's instructions.
- F. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- G. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- H. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- I. Identify control panels and major control components outside panels with plastic nameplates.
- J. Identify thermostats relating to terminal boxes or valves with nameplates.
- K. Identify valves in main and branch piping with tags.
- L. Identify air terminal units and radiator valves with numbered tags.
- M. Tag automatic controls, instruments, and relays. Key to control schematic.
- N. Identify piping, concealed or exposed, with plastic pipe markers, plastic tape pipe markers or stencilled painting. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- O. Identify ductwork with plastic nameplates or stencilled painting. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
- P. Locate ceiling tacks to locate valves, units, or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

### END OF SECTION

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# **SECTION 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC**

### PART 1 GENERAL

### **1.01 SECTION INCLUDES**

- A. Testing, adjustment, and balancing of air systems.
- B. Measurement of final operating condition of HVAC systems.
- C. Commissioning activities.

# **1.02 RELATED REQUIREMENTS**

A. Section 23 08 00 - Mechanical Systems Commissioning

# 1.03 REFERENCE STANDARDS

- A. AABC MN-1 AABC National Standards for Total System Balance; Associated Air Balance Council.
- B. ASHRAE Std 111 Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.
- C. NEBB (TAB) Procedural Standards for Testing Adjusting Balancing of Environmental Systems.
- D. SMACNA (TAB) HVAC Systems Testing, Adjusting and Balancing.

# 1.04 SUBMITTALS

- A. Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
- B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
  - 1. Submit to StudioJAED.
  - 2. Submit to the Commissioning Authority, Construction Manager, and HVAC controls contractor.
  - Submit six weeks prior to starting the testing, adjusting, and balancing work. 3.
  - Include certification that the plan developer has reviewed the contract documents, the 4. equipment and systems, and the control system with the StudioJAED and other installers to sufficiently understand the design intent for each system.
  - 5. Include at least the following in the plan:
    - a. Preface: An explanation of the intended use of the control system.
    - List of all air flow, water flow, sound level, system capacity and efficiency b. measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
    - Copy of field checkout sheets and logs to be used, listing each piece of equipment to C. be tested, adjusted and balanced with the data cells to be gathered for each.
    - Identification and types of measurement instruments to be used and their most recent d. calibration date.
    - e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
    - Final test report forms to be used. f.
    - Detailed step-by-step procedures for TAB work for each system and issue, including: g. Terminal flow calibration (for each terminal type).
      - 1)
      - 2) Diffuser proportioning.
      - Branch/submain proportioning. 3)
      - 4) Total flow calculations.
      - 5) Rechecking.
      - 6) Diversity issues.

- h. Expected problems and solutions, etc.
- i. Criteria for using air flow straighteners or relocating flow stations and sensors .
- j. Details of how TOTAL flow will be determined; for example:
  - 1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
  - 2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
- k. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
- I. Confirmation of understanding of the outside air ventilation criteria under all conditions.
- m. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
- n. Method of checking building static and exhaust fan and/or relief damper capacity.
- o. Proposed selection points for sound measurements and sound measurement methods.
- p. Methods for making coil or other system plant capacity measurements, if specified.
- q. Time schedule for TAB work to be done in phases (by floor, etc.).
- r. Description of TAB work for areas to be built out later, if any.
- s. Time schedule for deferred or seasonal TAB work, if specified.
- t. False loading of systems to complete TAB work, if specified.
- u. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
- v. Interstitial cavity differential pressure measurements and calculations, if specified.
- w. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
- x. Procedures for formal progress reports, including scope and frequency.
- y. Procedures for formal deficiency reports, including scope, frequency and distribution.
- C. Field Logs: Submit at least once a week to Commissioning Authority and Construction Manager.
- D. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.
- E. Progress Reports.
- F. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
  - 1. Submit to the Commissioning Authority, Construction Manager, and HVAC controls contractor within two weeks after completion of testing, adjusting, and balancing.
  - 2. Revise TAB plan to reflect actual procedures and submit as part of final report.
  - 3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for StudioJAED and for inclusion in operating and maintenance manuals.
  - 4. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
  - 5. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
  - 6. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
  - 7. Units of Measure: Report data in I-P (inch-pound) units only.

- 8. Include the following on the title page of each report:
  - a. Name of Testing, Adjusting, and Balancing Agency.
  - b. Address of Testing, Adjusting, and Balancing Agency.
  - c. Telephone number of Testing, Adjusting, and Balancing Agency.
  - d. Project name.
  - e. Project location.
  - f. Project StudioJAED.
  - g. Project Engineer.
  - h. Project Contractor.
  - i. Project altitude.
  - j. Report date.
- G. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

### 1.05 QUALITY ASSURANCE (MOVED TO PART 3)

### 1.06 PRE-BALANCING MEETING (MOVED TO PART 3)

### 1.07 SEQUENCING AND SCHEDULING (MOVED TO PART 3)

### 1.08 WARRANTY (MOVED TO PART 3)

### PART 2 PRODUCTS - NOT USED

### PART 3 EXECUTION

### 3.01 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
  - 1. AABC MN-1, AABC National Standards for Total System Balance.
  - 2. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
  - 3. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.
  - 4. SMACNA HVAC Systems Testing, Adjusting, and Balancing.
  - 5. Maintain at least one copy of the standard to be used at project site at all times.
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
  - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
  - 2. Having minimum of three years documented experience.
  - 3. Certified by one of the following:
    - a. AABC, Associated Air Balance Council: www.aabchq.com; upon completion submit AABC National Performance Guaranty.
    - b. NEBB, National Environmental Balancing Bureau: www.nebb.org.
    - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org.
- E. TAB Supervisor Qualifications: Certified by same organization as TAB agency.
- F. TAB Supervisor Qualifications: Professional Engineer licensed in Delaware.

### 3.02 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
  - 1. Systems are started and operating in a safe and normal condition.
  - 2. Temperature control systems are installed complete and operable.
  - 3. Proper thermal overload protection is in place for electrical equipment.
  - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
  - 5. Duct systems are clean of debris.
  - 6. Fans are rotating correctly.
  - 7. Fire and volume dampers are in place and open.
  - 8. Air coil fins are cleaned and combed.
  - 9. Access doors are closed and duct end caps are in place.
  - 10. Air outlets are installed and connected.
  - 11. Duct system leakage is minimized.
  - 12. Hydronic systems are flushed, filled, and vented.
  - 13. Pumps are rotating correctly.
  - 14. Proper strainer baskets are clean and in place.
  - 15. Service and balance valves are open.
- B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- C. Beginning of work means acceptance of existing conditions.

#### 3.03 PREPARATION

- A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
  - 1. Require attendance by all installers whose work will be tested, adjusted, or balanced.
- B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to StudioJAED to facilitate spot checks during testing.
- C. Provide additional balancing devices as required.

### 3.04 ADJUSTMENT TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 10 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 10 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
- C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

#### 3.05 RECORDING AND ADJUSTING

- A. Field Logs: Maintain written logs including:
  - 1. Running log of events and issues.
  - 2. Discrepancies, deficient or uncompleted work by others.
  - 3. Contract interpretation requests.
  - 4. Lists of completed tests.
- B. Ensure recorded data represents actual measured or observed conditions.
- C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- D. Mark on the drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

- E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Caesar Rodney School District.
- H. Check and adjust systems approximately six months after final acceptance and submit report.

### 3.06 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities .
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- F. Vary total system air quantities by adjustment of fan speeds. Provide drive and sheave changes required. Vary branch air quantities by damper regulation.
- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.
- M. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.
- N. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.
- O. On fan powered VAV boxes, adjust air flow switches for proper operation.
- P. For laboratories, lab classrooms, and prep rooms, offset CFM values (differential between exhaust/return and supply airflows) shall be required to maintain a plus 10% minus 5% offset.
- Q. All ductwork is to be leak-tested.

### 3.07 COMMISSIONING

A. Perform prerequisites prior to starting commissioning activities.

- B. Fill out Prefunctional Checklists for:
  - 1. Air side systems.
  - 2. Water side systems.
- C. Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.
- D. Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for 10 percent of the air handlers plus a random sample equivalent to 5 percent of the final TAB report data as directed by Commissioning Authority.
  - 1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
  - 2. Use the same test instruments as used in the original TAB work.
  - 3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
  - 4. For purposes of re-check, failure is defined as follows:
    - a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
    - b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
    - c. Temperatures: Deviation of more than one degree F.
    - d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
    - e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.
  - 5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.
- E. In the presence of the Commissioning Authority, verify that:
  - 1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
  - 2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.
  - 3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.
- F. No seasonal tests are required.
- G. No further monitoring is required.
- H. No deferred testing is required.

### 3.08 SCOPE

- A. Test, adjust, and balance the following:
  - 1. Plumbing Pumps

- 2. Air Cooled Refrigerant Condensers.
- 3. Air Coils.
- 4. Terminal Heat Transfer Units
- 5. Air Handling Units (Including VRF Fan Coils)
- 6. Energy Recovery Units (Including Duct-Mounted Heating Coils)
- 7. Packaged Rooftop Units
- 8. Fans
- 9. Air Filters
- 10. Air Inlets and Outlets

# 3.09 MINIMUM DATA TO BE REPORTED

- A. Electric Motors:
  - 1. Manufacturer
  - 2. Model/Frame
  - 3. HP/BHP
  - 4. Phase, voltage, amperage; nameplate, actual, no load
  - 5. RPM
  - 6. Service factor
  - 7. Starter size, rating, heater elements
  - 8. Sheave Make/Size/Bore
- B. V-Belt Drives:
  - 1. Identification/location
  - 2. Required driven RPM
  - 3. Driven sheave, diameter and RPM
  - 4. Belt, size and quantity
  - 5. Motor sheave diameter and RPM
  - 6. Center to center distance, maximum, minimum, and actual
- C. Pumps:
  - 1. Identification/number
  - 2. Manufacturer
  - 3. Size/model
  - 4. Impeller
  - 5. Service
  - 6. Design flow rate, pressure drop, BHP
  - 7. Actual flow rate, pressure drop, BHP
  - 8. Discharge pressure
  - 9. Suction pressure
  - 10. Total operating head pressure
  - 11. Shut off, discharge and suction pressures
  - 12. Shut off, total head pressure
- D. Air Cooled Condensers:
  - 1. Identification/number
  - 2. Location
  - 3. Manufacturer
  - 4. Model number
  - 5. Serial number
  - 6. Entering DB air temperature, design and actual
  - 7. Leaving DB air temperature, design and actual
  - 8. Number of compressors
- E. Cooling Coils:

- 1. Identification/number
- 2. Location
- 3. Service
- 4. Manufacturer
- 5. Air flow, design and actual
- 6. Entering air DB temperature, design and actual
- 7. Entering air WB temperature, design and actual
- 8. Leaving air DB temperature, design and actual
- 9. Leaving air WB temperature, design and actual
- 10. Water flow, design and actual
- 11. Water pressure drop, design and actual
- 12. Entering water temperature, design and actual
- 13. Leaving water temperature, design and actual
- 14. Saturated suction temperature, design and actual
- 15. Air pressure drop, design and actual
- F. Heating Coils:
  - 1. Identification/number
  - 2. Location
  - 3. Service
  - 4. Manufacturer
  - 5. Air flow, design and actual
  - 6. Water flow, design and actual
  - 7. Water pressure drop, design and actual
  - 8. Entering water temperature, design and actual
  - 9. Leaving water temperature, design and actual
  - 10. Entering air temperature, design and actual
  - 11. Leaving air temperature, design and actual
  - 12. Air pressure drop, design and actual
- G. Electric Duct Heaters:
  - 1. Manufacturer
  - 2. Identification/number
  - 3. Location
  - 4. Model number
  - 5. Design kW
  - 6. Number of stages
  - 7. Phase, voltage, amperage
  - 8. Test voltage (each phase)
  - 9. Test amperage (each phase)
  - 10. Air flow, specified and actual
  - 11. Temperature rise, specified and actual
- H. Air Moving Equipment:
  - 1. Location
  - 2. Manufacturer
  - 3. Model number
  - 4. Serial number
  - 5. Arrangement/Class/Discharge
  - 6. Air flow, specified and actual
  - 7. Return air flow, specified and actual
  - 8. Outside air flow, specified and actual
  - 9. Total static pressure (total external), specified and actual

- 10. Inlet pressure
- 11. Discharge pressure
- 12. Sheave Make/Size/Bore
- 13. Number of Belts/Make/Size
- 14. Fan RPM

Ι.

- Return Air/Outside Air:
  - 1. Identification/location
  - 2. Design air flow
  - 3. Actual air flow
  - 4. Design return air flow
  - 5. Actual return air flow
  - 6. Design outside air flow
  - 7. Actual outside air flow
  - 8. Return air temperature
  - 9. Outside air temperature
  - 10. Required mixed air temperature
  - 11. Actual mixed air temperature
  - 12. Design outside/return air ratio
  - 13. Actual outside/return air ratio
- J. Exhaust Fans:
  - 1. Location
  - 2. Manufacturer
  - 3. Model number
  - 4. Serial number
  - 5. Air flow, specified and actual
  - 6. Total static pressure (total external), specified and actual
  - 7. Inlet pressure
  - 8. Discharge pressure
  - 9. Sheave Make/Size/Bore
  - 10. Number of Belts/Make/Size
  - 11. Fan RPM
  - 12. Associated with Fume Hoods, Include:
    - a. Face velocity test at max/min sash position.
- K. Duct Traverses:
  - 1. System zone/branch
  - 2. Duct size
  - 3. Area
  - 4. Design velocity
  - 5. Design air flow
  - 6. Test velocity
  - 7. Test air flow
  - 8. Duct static pressure
  - 9. Air temperature
  - 10. Air correction factor
- L. Duct Leak Tests:
  - 1. Description of ductwork under test
  - 2. Duct design operating pressure
  - 3. Duct design test static pressure
  - 4. Duct capacity, air flow
  - 5. Maximum allowable leakage duct capacity times leak factor

- 6. Test apparatus
  - a. Blower
  - b. Orifice, tube size
  - c. Orifice size
  - d. Calibrated
- 7. Test static pressure
- 8. Test orifice differential pressure
- 9. Leakage
- M. Air Monitoring Stations:
  - 1. Identification/location
  - 2. System
  - 3. Size
  - 4. Area
  - 5. Design velocity
  - 6. Design air flow
  - 7. Test velocity
  - 8. Test air flow
- N. Air Distribution Tests:
  - 1. Air terminal number
  - 2. Room number/location
  - 3. Terminal type
  - 4. Terminal size
  - 5. Area factor
  - 6. Design velocity
  - 7. Design air flow
  - 8. Test (final) velocity
  - 9. Test (final) air flow
  - 10. Percent of design air flow

# **END OF SECTION**

# SECTION 23 07 13 DUCT INSULATION

### PART 1 GENERAL

# 1.01 SECTION INCLUDES

- A. Duct insulation.
- B. Duct Lagging.
- C. Insulation jackets.

# 1.02 RELATED REQUIREMENTS

- A. Section 09 90 00 Painting and Coating: Painting insulation jackets.
- B. Section 22 05 53 Identification for Plumbing Piping and Equipment.
- C. Section 23 05 53 Identification for HVAC Piping and Equipment.
- D. Section 23 31 00 HVAC Ducts and Casings: Glass fiber ducts.

# 1.03 REFERENCE STANDARDS

- A. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- B. ASTM B209M Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].
- C. ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- D. ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- E. ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- F. ASTM C916 Standard Specification for Adhesives for Duct Thermal Insulation.
- G. ASTM C1071 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
- H. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.
- I. ASTM E96/E96M Standard Test Methods for Water Vapor Transmission of Materials.
- J. ASTM G21 Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- K. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association.
- L. SMACNA (DCS) HVAC Duct Construction Standards Metal and Flexible.
- M. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials.

### 1.04 SUBMITTALS

- A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- B. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of experienceand approved by manufacturer.

### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

### 1.07 FIELD CONDITIONS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

### PART 2 PRODUCTS

### 2.01 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION

A. Surface Burning Characteristics: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.

### 2.02 GLASS FIBER, FLEXIBLE

- A. Manufacturer:
  - 1. Knauf Insulation: www.knaufusa.com.
  - 2. Johns Manville Corporation: www.jm.com.
  - 3. Owens Corning Corp: www.owenscorning.com.
  - 4. CertainTeed Corporation: www.certainteed.com.
- B. Insulation: ASTM C553; flexible, noncombustible blanket.
  - 1. Minimum "R" Value: Minimum R value of (6) is required for interior installations and a minimum R value of (8) is required for exterior installations.
  - 2. Maximum Service Temperature: 450 degrees F.
  - 3. Maximum Water Vapor Sorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket:
  - 1. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  - 2. Secure with pressure sensitive tape.
- D. Vapor Barrier Tape:
  - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- E. Outdoor Vapor Barrier Mastic:
  - 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- F. Tie Wire: Annealed steel, 16 gage.

#### 2.03 GLASS FIBER, RIGID

- A. Manufacturer:
  - 1. Knauf Insulation: www.knaufusa.com.
  - 2. Johns Manville Corporation: www.jm.com.
  - 3. Owens Corning Corp: www.owenscorning.com.
  - 4. CertainTeed Corporation: www.certainteed.com.
- B. Insulation: ASTM C612; rigid, noncombustible blanket.
  - 1. Minimum "R" Value: Minimum R value of (6) is required for interior installations and a minimum R value of (8) is required for exterior installations.
  - 2. Maximum service temperature: 450 degrees F.
  - 3. Maximum Water Vapor Sorption: 5.0 percent.

- C. Vapor Barrier Jacket:
  - 1. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  - 2. Secure with pressure sensitive tape.
- D. Vapor Barrier Tape:
  - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- E. Indoor Vapor Barrier Finish:
  - 1. Cloth: Untreated; 9 oz/sq yd weight, glass fabric.
  - 2. Vinyl emulsion type acrylic, compatible with insulation, black color.

### 2.04 JACKETS

- A. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
  - 1. Lagging Adhesive:
    - a. Compatible with insulation.
- B. Aluminum Jacket: ASTM B209 (ASTM B209M).
  - 1. Thickness: 0.016 inch sheet.
  - 2. Finish: Smooth.
  - 3. Joining: Longitudinal slip joints and 2 inch laps.
  - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
  - 5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
  - 6. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

# 2.05 DUCT LAGGING

- A. Manufacturers:
  - 1. Sound Seal: www.soundseal.com
  - 2. Kinetics Noise Control: www.kineticsnoise.com.
  - 3. Substitutions: See Section 01 60 00 Product Requirements.
- B. Lagging: Loaded vinyl noise barrier with a scrim reinforced aluminum foil facing on one side with a 1" thick fiberglass decoupler.
  - 1. Apparent Thermal Conductivity: Maximum of.25 at 75 degrees F
  - 2. Service Temperature: Up to 350 degrees F.
- C. Adhesive: Waterproof, fire-retardant type, ASTM C916.

### PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that ducts have been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

#### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Insulated ducts conveying air below ambient temperature:
  - 1. Provide insulation with vapor barrier jackets.
  - 2. Finish with tape and vapor barrier 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.

- D. Insulated ducts conveying air above ambient temperature:
  - 1. Provide with or without standard vapor barrier jacket.
  - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- E. Exterior Applications: Provide insulation with vapor barrier jacket. Cover with with calked aluminum jacket with seams located on bottom side of horizontal duct section.
- F. External Duct Insulation Application:
  - 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
  - 2. Secure insulation without vapor barrier with staples, tape, or wires.
  - 3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
  - 4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
  - 5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

### 3.03 SCHEDULES

- A. INDOOR DUCT AND PLENUM APPLICATION SCHEDULE
  - 1. NOTE: Apply duct lagging where indicated on drawings.
  - 2. Service: Round, supply-air ducts, concealed.
    - a. Material: Mineral-fiber blanket.
      - b. Thickness: 2 inches.
      - c. Minimum "R" value: 6.
      - d. Jacket: Foil and paper.
      - e. Vapor Retarder Required: Yes.
  - 3. Service: Round, return-air ducts, concealed.
    - a. Material: Mineral-fiber blanket.
    - b. Thickness: 2 inches.
    - c. Minimum "R" value: 6.
    - d. Jacket: Foil and paper.
    - e. Vapor Retarder Required: No.
  - 4. Service: Round, outside-air ducts, concealed.
    - a. Material: Mineral-fiber blanket
    - b. Thickness: 2 inches.
    - c. Minimum "R" value: 6.
    - d. Jacket: Foil and paper.
    - e. Vapor Retarder Required: Yes.
  - 5. Service: Rectangular, supply-air ducts, concealed.
    - a. Material: Mineral-fiber blanket
    - b. Thickness: 2 inches.
    - c. Minimum "R" value: 6.
    - d. Jacket: Foil and paper.
    - e. Vapor Retarder Required: Yes.
  - 6. Service: Rectangular, return-air ducts, concealed.
    - a. Material: Mineral-fiber blanket
    - b. Thickness: 2 inches.
    - c. Minimum "R" value: 6.
    - d. Jacket: Foil and paper.
    - e. Vapor Retarder Required: No.
  - 7. Service: Rectangular, outside-air ducts, concealed.
    - a. Material: Mineral-fiber blanket
8.

- b. Thickness: 2 inches.
- c. Minimum "R" value: 6.
- d. Jacket: Foil and paper.
- e. Vapor Retarder Required: Yes.
- Service: Round, supply-air ducts, exposed.
  - a. Material: Mineral-fiber blanket
  - b. Thickness: 2 inches.
  - c. Minimum "R" value: 6.
  - d. Jacket: Spiral-wound steel, paintable.
  - e. Vapor Retarder Required: Yes.
  - f. NOTE: Provide double-wall, insulated, painted spiral ductwork in areas noted on drawings and where not concealed above ceilings. Color to be selected by architect.
- 9. Service: Round, return-air ducts, exposed.
  - a. Material: Mineral-fiber blanket.
  - b. Thickness: 2 inches.
  - c. Minimum "R" value: 6.
  - d. Jacket: Spiral-wound steel, paintable.
  - e. Vapor Retarder Required: No.
  - f. NOTE: Provide double-wall, insulated, painted spiral ductwork in areas noted on drawings and where not concealed above ceilings. Color to be selected by architect.
- 10. Service: Round, outside-air ducts, exposed.
  - a. Material: Mineral-fiber blanket.
  - b. Thickness: 2 inches.
  - c. Minimum "R" value: 6.
  - d. Jacket: Spiral-wound steel, paintable.
  - e. Vapor Retarder Required: Yes.
  - f. NOTE: Provide double-wall, insulated, painted spiral ductwork in areas noted on drawings and where not concealed above ceilings. Color to be selected by architect.
- 11. Service: Rectangular, supply-air ducts, exposed.
  - a. Material: Mineral-fiber board.
  - b. Thickness: 2 inches.
  - c. Minimum "R" value: 6.
  - d. Jacket: Aluminum, painted. Color to be selected by architect.
  - e. Vapor Retarder Required: Yes.
- 12. Service: Rectangular, return-air ducts, exposed.
  - a. Material: Mineral-fiber board.
  - b. Thickness: 2 inches.
  - c. Minimum "R" value: 6.
  - d. Jacket: Aluminum, painted. Color to be selected by architect.
  - e. Vapor Retarder Required: No.
- 13. Service: Rectangular, outside-air ducts, exposed.
  - a. Material: Mineral-fiber board.
  - b. Thickness: 2 inches.
  - c. Minimum "R" value: 6.
  - d. Jacket: Aluminum, painted. Color to be selected by architect.
  - e. Vapor Retarder Required: Yes.
- B. OUTDOOR DUCT AND PLENUM APPLICATION SCHEDULE
  - 1. Service: Round, supply-air ducts.
    - a. Material: Mineral-fiber board.
      - b. Thickness: 3 inches.
      - c. Minimum "R" value: 8.

- d. Field-Applied Jacket: aluminum1) Aluminum Thickness: 0.032 inch
- e. Vapor Retarder Required: Yes.
- 2. Service: Round, return-air ducts.
  - a. Material: Mineral-fiber board.
  - b. Thickness: 3 inches.
  - c. Minimum "R" value: 8.
  - d. Field-Applied Jacket: aluminum1) Aluminum Thickness: 0.032 inch
  - e. Vapor Retarder Required: Yes.
- 3. Service: Rectangular, supply-air ducts.
  - a. Material: Mineral-fiber board.
  - b. Thickness: 3 inches.
  - c. Minimum "R" value: 8.
  - d. Field-Applied Jacket: aluminum
    - 1) Aluminum Thickness: 0.032 inch
  - e. Vapor Retarder Required: Yes.
- 4. Service: Rectangular, return-air ducts.
  - a. Material: Mineral-fiber board.
  - b. Thickness: 3 inches.
  - c. Minimum "R" value: 8.
  - d. Field-Applied Jacket: aluminum1) Aluminum Thickness: 0.032 inch
  - e. Vapor Retarder Required: Yes.

# END OF SECTION

# SECTION 23 07 19 HVAC PIPING INSULATION

### PART 1 GENERAL

### 1.01 SECTION INCLUDES

- A. Piping insulation.
- B. Jackets and accessories.

### 1.02 RELATED REQUIREMENTS

- A. Section 07 84 00 Firestopping.
- B. Section 09 90 00 Painting and Coating: Painting insulation jacket.
- C. Section 22 10 05 Plumbing Piping: Placement of hangers and hanger inserts.
- D. Section 23 21 13 Hydronic Piping: Placement of hangers and hanger inserts.
- E. Section 23 23 00 Refrigerant Piping: Placement of inserts.

#### 1.03 REFERENCE STANDARDS

- A. ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
- B. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- C. ASTM B209M Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].
- D. ASTM C177 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- E. ASTM C195 Standard Specification for Mineral Fiber Thermal Insulating Cement.
- F. ASTM C449 Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
- G. ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- H. ASTM C533 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
- I. ASTM C534/C534M Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- J. ASTM C547 Standard Specification for Mineral Fiber Pipe Insulation.
- K. ASTM C552 Standard Specification for Cellular Glass Thermal Insulation.
- L. ASTM C578 Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
- M. ASTM C585 Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
- N. ASTM C591 Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
- O. ASTM C610 Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation.
- P. ASTM C795 Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- Q. ASTM D1056 Standard Specification for Flexible Cellular Materials--Sponge or Expanded Rubber.
- R. ASTM D2842 Standard Test Method for Water Absorption of Rigid Cellular Plastics.

- S. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.
- T. ASTM E96/E96M Standard Test Methods for Water Vapor Transmission of Materials.
- U. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association.
- V. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials.

#### 1.04 SUBMITTALS

- A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- B. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

#### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum three years of experience.

### 1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

#### 1.07 FIELD CONDITIONS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

#### PART 2 PRODUCTS

### 2.01 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION

A. Surface Burning Characteristics: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.

#### 2.02 GLASS FIBER

- A. Manufacturers:
  - 1. Knauf Insulation: www.knaufusa.com.
  - 2. Johns Manville Corporation: www.jm.com.
  - 3. Owens Corning Corp: www.owenscorning.com.
  - 4. CertainTeed Corporation: www.certainteed.com.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
  - 1. 'K' value: ASTM C177, 0.24 at 75 degrees F.
  - 2. Maximum service temperature: 850 degrees F.
  - 3. Maximum moisture absorption: 0.2 percent by volume.
- C. Insulation: ASTM C547 and ASTM C795; semi-rigid, noncombustible, end grain adhered to jacket.
  - 1. 'K' value: ASTM C177, 0.24 at 75 degrees F.
  - 2. Maximum service temperature: 650 degrees F.
  - 3. Maximum moisture absorption: 0.2 percent by volume.
- D. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
- E. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.

- F. Vapor Barrier Lap Adhesive:
  - 1. Compatible with insulation.
- G. Insulating Cement/Mastic:
  - 1. ASTM C195; hydraulic setting on mineral wool.
- H. Fibrous Glass Fabric:
  - 1. Cloth: Untreated; 9 oz/sq yd weight.
  - 2. Blanket: 1.0 lb/cu ft density.
  - 3. Weave: 5x5.
- I. Indoor Vapor Barrier Finish:
  - 1. Cloth: Untreated; 9 oz/sq yd weight.
  - 2. Vinyl emulsion type acrylic, compatible with insulation, black color.
- J. Outdoor Vapor Barrier Mastic:
  - 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- K. Outdoor Breather Mastic:
  - 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- L. Insulating Cement:
  - 1. ASTM C449/C449M.

# 2.03 CELLULAR GLASS

- A. Manufacturers:
  - 1. Pittsburgh Corning Corporation: www.foamglasinsulation.com.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Insulation: ASTM C552, Grade 1.
  - 1. 'K' value: 0.37 at 100 degrees F.
  - 2. Service Temperature: Up to 900 degrees F.
  - 3. Water Vapor Permeability: 0.005 perm inch.
  - 4. Water Absorption: 0.2 percent by volume, maximum.

# 2.04 EXPANDED POLYSTYRENE

- A. Insulation: ASTM C578; rigid closed cell.
  - 1. 'K' value: 0.23 at 75 degrees F.
  - 2. Maximum service temperature: 165 degrees F.
  - 3. Maximum water vapor permeance: 5.0 perms

# 2.05 EXPANDED PERLITE

- A. Manufacturers:
  - 1. Schundler Company: www.schundler.com.
- B. Insulation: ASTM C610, molded.
  - 1. Maximum service temperature: 1200 degrees F.
  - 2. Maximum water vapor transmission: 0.1 perm.

# 2.06 HYDROUS CALCIUM SILICATE

- A. Manufacturers:
  - 1. Johns Manville Corporation: www.jm.com.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Insulation: ASTM C533 and ASTM C795; rigid molded, asbestos free, gold color.
  - 1. 'K' value: 2 and C518; 0.40 at 300 degrees F, when tested in accordance with 2 or 1.
  - 2. Maximum service temperature: 1200 degrees F.
  - 3. Density: 15 lb/cu ft.

- C. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- D. Insulating Cement:
  - 1. ASTM C449/C449M.

# 2.07 POLYISOCYANURATE CELLULAR PLASTIC

- A. Insulation Material: ASTM C591, rigid molded modified polyisocyanurate cellular plastic.
  - 1. Dimension: Comply with requirements of ASTM C585.
  - 2. 'K' Value: 0.18 at 75 degrees F, when tested in accordance with ASTM C518.
  - 3. 'K' value: 0.18 at 75 degrees F, when tested in accordance with 1.
  - 4. Minimum Service Temperature: -70 degrees F.
  - 5. Maximum Service Temperature: 300 degrees F.
  - 6. Water Absorption: 0.5 percent by volume, maximum, when tested in accordance with ASTM D2842..
  - 7. Moisture Vapor Transmission: 4.0 perm in.
  - 8. Connection: Waterproof vapor barrier adhesive.

### 2.08 POLYETHYLENE

- A. Manufacturers:
  - 1. Armacell International: www.armacell.com.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Insulation: Flexible closed-cell polyethylene tubing, slit lengthwise for installation, complying with applicable requirements of ASTM D1056.
  - 1. 'K' value: ASTM C177; 0.25 at 75 degrees F.
  - 2. Maximum Service Temperature: 200 degrees F.
  - 3. Density: 2 lb/cu ft.
  - 4. Maximum Moisture Absorption: 1.0 percent by volume.
  - 5. Moisture Vapor Permeability: 0.05 perm inch, when tested in accordance with ASTM E96/E96M.
  - 6. Connection: Contact adhesive.

### 2.09 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Manufacturer:
  - 1. Armacell International: www.armacell.com.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534 Grade 3; use molded tubular material wherever possible.
  - 1. Minimum Service Temperature: -40 degrees F.
  - 2. Maximum Service Temperature: 220 degrees F.
  - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

### 2.10 JACKETS

- A. PVC Plastic.
  - 1. Manufacturers:
    - a. Johns Manville Corporation: www.jm.com.
    - b. Substitutions: See Section 01 60 00 Product Requirements.
  - 2. Jacket: One piece molded type fitting covers and sheet material, off-white color.
    - a. Minimum Service Temperature: 0 degrees F.
    - b. Maximum Service Temperature: 150 degrees F.
    - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.

- d. Thickness: 10 mil.
- e. Connections: Brush on welding adhesive.
- 3. Covering Adhesive Mastic:
  - a. Compatible with insulation.
- B. ABS Plastic:
  - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
    - a. Minimum Service Temperature: -40 degrees F.
    - b. Maximum Service Temperature of 180 degrees F.
    - c. Moisture Vapor Permeability: 0.012 perm inch, when tested in accordance with ASTM E96/E96M.
    - d. Thickness: 30 mil.
    - e. Connections: Brush on welding adhesive.
- C. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
  - 1. Lagging Adhesive:
    - a. Compatible with insulation.
- D. Aluminum Jacket: ASTM B209 (ASTM B209M) formed aluminum sheet.
  - 1. Thickness: 0.016 inch sheet.
  - 2. Finish: Smooth.
  - 3. Joining: Longitudinal slip joints and 2 inch laps.
  - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
  - 5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
  - 6. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.
- E. Stainless Steel Jacket: ASTM A666, Type 302 stainless steel.
  - 1. Thickness: 0.010 inch.
  - 2. Finish: Smooth.
  - 3. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

# PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.
- D. Insulated pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- E. Glass fiber insulated pipes conveying fluids below ambient temperature:
  - 1. Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
  - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

- G. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- H. Glass fiber insulated pipes conveying fluids above ambient temperature:
  - 1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
  - 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.
- I. Inserts and Shields:
  - 1. Application: Piping 1-1/2 inches diameter or larger.
  - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
  - 3. Insert location: Between support shield and piping and under the finish jacket.
  - 4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
  - 5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- J. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 07 84 00.
- K. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with canvas jacket sized for finish painting.
- L. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping. Provide two coats of UV resistant finish for flexible elastomeric cellular insulation without jacketing.
- M. Buried Piping: Provide factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with one mil thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.
- N. Heat Traced Piping: 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. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

### 3.03 SCHEDULE

- A. PIPING INSULATION SCHEDULES
  - 1. General: Abbreviations used in the following schedules include:
    - a. Field Applied Jackets: P PVC, K-Foil and Paper, A Aluminum, SS Stainless Steel.
    - b. Piping Sizes: NPS Nominal Pipe Size.
- B. INTERIOR PIPING APPLICATION SCHEDULE
  - 1. Service: Condensate drain piping.
    - a. Operating Temperature: 35 to 75 deg F.
    - b. Insulation Material: Flexible elastomeric.
    - c. Insulation Thickness: 0.5 inch.
    - d. Jacket: PVC where not concealed above ceilings.
    - e. Vapor Retarder Required: Yes.
    - f. Finish: None.
- C. Service: Refrigerant suction, liquid, and hot-gas piping.
  - 1. Operating Temperature: 35 to 140 deg F.
  - 2. Insulation Material: Flexible elastomeric.

- Insulation Thickness: Apply the following insulation thicknesses:
  a. Pipe, 1" or less: 1.0 inch.
  - b. Pipe, 1-1/4" and up: 1.5 inch.
- 4. Jacket: PVC where not conealed above ceilings.
- 5. Vapor Retarder Required: Yes.
- 6. Finish: None.
- D. EXTERIOR PIPING INSULATION APPLICATION SCHEDULE
- E. Service: Refrigerant suction, liquid, and hot gas piping.
  - 1. Operating Temperature: 35 to 140 deg F.
  - 2. Insulation Material: Flexible elastomeric.
  - 3. Insulation Thickness: Apply the following insulation thicknesses:
    - a. Pipe, 1" or less: 1.0 inch.
    - b. Pipe, 1-1/4" to 2": 1.5 inch.
    - c. Pipe, 2-1/2" and up: 1.5 inch.
  - 4. Jacket: Aluminum.
  - 5. Vapor Retarder Required: Yes.
  - 6. Finish: None.

# END OF SECTION

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# SECTION 23 08 00 COMMISSIONING OF HVAC

#### PART 1 GENERAL

### 1.01 SUMMARY

- A. This section covers the Contractor's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.
- B. The following HVAC equipment is to be commissioned, including commissioning activities for the following specific items:
  - 1. Control system.
  - 2. Variable refrigerant flow (VRF) system.
  - 3. Energy recovery ventilators.
  - 4. Variable frequency drives.
  - 5. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.
- C. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

#### 1.02 RELATED REQUIREMENTS

- A. Section 01 77 00 Closeout Submittals: Scope and procedures for operation and maintenance manuals and project record documents.
- B. Section 23 09 23 Direct-Digital Control System for HVAC.
- C. Section 23 09 13 Instrumentation and Control Devices for HVAC.
- D. Section 23 09 93 Sequence of Operations for HVAC Controls.
- E. Section 23 05 93 Testing, Adjusting, and Balancing for HVAC.

#### 1.03 REFERENCE STANDARDS

A. ASHRAE Guideline 1.1 - The HVAC Commissioning Process.

### 1.04 SUBMITTALS

- A. HVAC Control System Documentation: Submit detailed sequences of operation, control system drawings, and points list.
  - 1. Incorporate the sequence of operation information specified in other HVAC specification sections.
  - 2. Incorporate the shop drawing submittal information specified in the HVAC control system section.
  - 3. Submittals prepared for other sections may be used in preparation of this documentation.
- B. Updated Submittals: Keep the Commissioning Authority informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.
- C. DRAFT Prefunctional Checklists and Functional Test Procedures for Control System: Detailed written plan indicating the procedures to be followed to test, checkout and adjust the control system prior to full system Functional Testing; include at least the following for each type of equipment controlled:
  - 1. System name.
  - 2. List of devices.
  - 3. Step-by-step procedures for testing each controller after installation, including:
    - a. Process of verifying proper hardware and wiring installation.

- b. Process of downloading programs to local controllers and verifying that they are addressed correctly.
- c. Process of performing operational checks of each controlled component.
- d. Plan and process for calibrating valve and damper actuators and all sensors.
- e. Description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
- 4. Copy of proposed log and field checkout sheets to be used to document the process; include space for initial and final read values during calibration of each point and space to specifically indicate when a sensor or controller has "passed" and is operating within the contract parameters.
- 5. Description of the instrumentation required for testing.
- 6. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the Commissioning Authority and TAB contractor for this determination.
- D. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.
- E. HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:
  - 1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.
  - 2. Full as-built set of control drawings.
  - 3. Full as-built sequence of operations for each piece of equipment.
  - 4. Full points list; in addition to the information on the original points list submittal, include a listing of all rooms with the following information for each room:
    - a. Floor.
    - b. Room number.
    - c. Room name.
    - d. HVAC unit ID.
    - e. Reference drawing number.
    - f. Air terminal unit tag ID.
    - g. Heating and/or cooling valve tag ID.
    - h. Minimum air flow rate.
    - i. Maximum air flow rate.
  - 5. Full print out of all schedules and set points after testing and acceptance of the system.
  - 6. Full as-built print out of software program.
  - 7. Electronic copy on disk of the entire program for this facility.
  - 8. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.
  - 9. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
  - 10. Control equipment component submittals, parts lists, etc.
  - 11. Warranty requirements.
  - 12. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
  - 13. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
    - a. Sequences of operation.
    - b. Control drawings.
    - c. Points lists.

- d. Controller and/or module data.
- e. Thermostats and timers.
- f. Sensors and DP switches.
- g. Valves and valve actuators.
- h. Dampers and damper actuators.
- i. Program setups (software program printouts).
- F. Project Record Documents: See Section 01 78 00 for additional requirements.
  - 1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
  - 2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.
- G. Draft Training Plan: In addition to requirements specified in Section 01 79 00, include:
  - 1. Follow the recommendations of ASHRAE Guideline 1.
  - 2. Control system manufacturer's recommended training.
  - 3. Demonstration and instruction on function and overrides of any local packaged controls not controlled by the HVAC control system.
- H. Training Manuals: See Section 01 77 00 for additional requirements.
  - 1. Provide 1 extra copy of the controls training manuals in a separate manual from the O&M manuals.

### PART 2 PRODUCTS

# 2.01 TEST EQUIPMENT

- A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of the Owner.
- B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to the Owner; such equipment, tools, and instruments are to become the property of the Owner.

### PART 3 EXECUTION

### 3.01 PREPARATION

- A. Cooperate with the Commissioning Authority in development of the Prefunctional Checklists and Functional Test Procedures.
- B. Furnish additional information requested by the Commissioning Authority.
- C. Prepare a preliminary schedule for HVAC pipe and duct system testing, flushing and cleaning, equipment start-up and testing, adjusting, and balancing start and completion for use by the Commissioning Authority; update the schedule as appropriate.
- D. Notify the Commissioning Authority when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and testing, adjusting, and balancing will occur; when commissioning activities not yet performed or not yet scheduled will delay construction notify ahead of time and be proactive in seeing that the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.
- E. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.
  - 1. Include cost of sheaves and belt changes that may be required for testing, adjusting, and balancing.

- F. Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.
- G. Provide temperature and pressure taps in accordance with the contract documents.
  - 1. Provide a pressure/temperature plug at each water sensor that is an input point to the control system.

### 3.02 INSPECTING AND TESTING - GENERAL

- A. Submit startup plans, startup reports, and Prefunctional Checklists for each item of equipment or other assembly to be commissioned.
- B. Perform the Functional Tests directed by the Commissioning Authority for each item of equipment or other assembly to be commissioned.
- C. Provide two-way radios for use during the testing.
- D. Valve/Damper Stroke Setup and Check:
  - 1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
  - 2. Set pump/fan to normal operating mode.
  - 3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
  - 4. Command valve/damper open; verify position is full open and adjust output signal as required.
  - 5. Command valve/damper to a few intermediate positions.
  - 6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
  - 7. Closure for Heating Coil Valves Normally Open:
    - a. Set heating setpoint 20 degrees F above room temperature.
    - b. Observe valve open.
    - c. Remove control air or power from the valve and verify that the valve stem and actuator position do not change.
    - d. Restore to normal.
    - e. Set heating setpoint to 20 degrees F below room temperature.
    - f. Observe the valve close.
    - g. Restore to normal.
  - 8. Closure for Cooling Coil Valves Normally Closed:
    - a. Set cooling setpoint 20 degrees F above room temperature.
    - b. Observe the valve close.
    - c. Remove control air or power from the valve and verify that the valve stem and actuator position do not change.
    - d. Restore to normal.
    - e. Set cooling setpoint to 20 degrees F below room temperature.
    - f. Observe valve open.
    - g. Restore to normal.
- E. Coil Valve Leak Check:
  - 1. Method 1 Water Temperature With 2-Way Valve:
    - a. Calibrate water temperature sensors on each side of coil to be within 0.2 degree F of each other.
    - b. Turn off air handler fans, close outside air dampers. Keep pump running. Make sure appropriate coil dampers are open.
    - c. Normally closed valves will close.
    - d. Override normally open valves to the closed position.

- e. After 10 minutes observe water delta T across coil. If it is greater than 2 degrees F (, leakage is probably occurring.
- f. Reset valve stroke to close tighter.
- g. Repeat test until compliance is achieved.
- 2. Method 2 Air Temperature With 2 or 3-Way Valve: Water leak-by less than 10 percent will likely not be detected with this method.
  - a. Calibrate air temperature sensors on each side of coil to be within 0.2 degree F of each other.
  - b. Air handler fans should be on.
  - c. Change mixed or discharge air setpoint, override values or bleed or squeeze bulb pneumatic controller to cause the valve to close.
  - d. After 5 minutes observe air delta T across coil. If it is greater than one degree F (, leakage is probably occurring.
  - e. Reset valve stroke to close tighter.
  - f. Repeat test until compliance is achieved.
- F. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to the Owner.

# 3.03 TAB COORDINATION

- A. TAB: Testing, adjusting, and balancing of HVAC.
- B. Coordinate commissioning schedule with TAB schedule.
- C. Review the TAB plan to determine the capabilities of the control system toward completing TAB.
- D. Provide all necessary unique instruments and instruct the TAB technicians in their use; such as handheld control system interface for setting terminal unit boxes, etc.
- E. Have all required Prefunctional Checklists, calibrations, startup and component Functional Tests of the system completed and approved by the Commissioning Authority prior to starting TAB.
- F. Provide a qualified control system technician to operate the controls to assist the TAB technicians or provide sufficient training for the TAB technicians to operate the system without assistance.

# 3.04 CONTROL SYSTEM FUNCTIONAL TESTING

- A. Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of the Contract Documents and the detailed Sequences of Operation documentation submittal.
- B. Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with the contract documents.
- C. Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by the Commissioning Authority.
- D. Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
  - 1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to the Owner.
  - 2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.
- E. Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.

- F. Demonstrate the following to the Commissioning Authority during testing of controlled equipment; coordinate with commissioning of equipment.
  - 1. Setpoint changing features and functions.
  - 2. Sensor calibrations.
- G. Demonstrate to the Commissioning Authority:
  - 1. That all specified functions and features are set up, debugged and fully operable.
  - 2. That scheduling features are fully functional and setup, including holidays.
  - 3. That all graphic screens and value readouts are completed.
  - 4. Correct date and time setting in central computer.
  - 5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to the Owner.
  - 6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no extra cost to the Owner.
  - 7. Power failure and battery backup and power-up restart functions.
  - 8. Global commands features.
  - 9. Security and access codes.
  - 10. Occupant over-rides (manual, telephone, key, keypad, etc.).
  - 11. O&M schedules and alarms.
  - 12. Occupancy sensors and controls.
  - 13. "After hours" use tracking and billing.
  - 14. Communications to remote sites.
  - 15. Fire alarm interlocks and response.
  - 16. Fire protection and suppression systems interfaces.
  - 17. Security system interlocks.
  - 18. That points that are monitored only, having no control function, are reporting properly to the control system.
  - 19. All control strategies and sequences not tested during controlled equipment testing.
  - 20. Trend logging and graphing features that are specified.
  - 21. Other integrated tests specified in the contract documents
  - 22. That control system features that are included but not specified to be setup are actually installed.
- H. Perform and submit trend logging on the following using the control system, for minimum period of 5 days including one weekend, if the control points are monitored by the control system:
  - 1. Duty cycling, if specified.
  - 2. Demand limiting, including over-ride of limiting.
  - 3. Sequential staging ON of equipment; optionally demonstrate manually.
  - 4. Optimum start-stop functions.
  - 5. Miscellaneous equipment current or status for duty cycling and demand limiting.
  - 6. Equipment or building kW or current for demand limiting.
  - 7. Equipment optimum start/stop functions.
  - 8. All space temperature logs, taken at a maximum of 10 minute intervals.
- I. If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to the Owner.

# 3.05 OPERATION AND MAINTENANCE MANUALS

A. See Owner Front End for additional requirements.

- B. Add design intent documentation furnished by StudioJAED to manuals prior to submission to the Owner.
- C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.
- D. Commissioning Authority will add commissioning records to manuals after submission to the Owner.

#### 3.06 DEMONSTRATION AND TRAINING

- A. See Section 01 77 00 for additional requirements.
- B. Demonstrate operation and maintenance of HVAC system to Owner's personnel; if during any demonstration, the system fails to perform in accordance with the information included in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.
- C. These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to the Commissioning Authority during Functional Testing.
- D. Provide classroom and hands-on training of Caesar Rodney School District's designated personnel on operation and maintenance of the HVAC system, control system, and all equipment items indicated to be commissioned. Provide the following minimum durations of training:
  - 1. HVAC Control System: 8 hours.
  - 2. Variable Speed Drives: 2 hours.
  - 3. Variable Refrigerant Flow (VRF) System: 4 hours.
  - 4. Energy Recovery Ventilators: 2 hours.
- E. TAB Review: Instruct Owner's personnel for minimum 4 hours, after completion of TAB, on the following:
  - 1. Review final TAB report, explaining the layout and meanings of each data type.
  - 2. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
  - 3. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
  - 4. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
  - 5. Other salient information that may be useful for facility operations, relative to TAB.
- F. HVAC Control System Training: Perform training in at least three phases:
  - 1. Phase 1 Basic Control System: Provide minimum of 4 hours of actual training on the control system itself. Upon completion of training, each attendee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
    - a. This training is to be held at the project site.
  - 2. Phase 2 Integrating with HVAC Systems: Provide minimum of 4 hours of on-site, hands-on training after completion of Functional Testing. Include instruction on:
    - a. The specific hardware configuration of installed systems in this facility and specific instruction for operating the installed system, including interfaces with other systems, if any.
    - b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.

- c. Trend logging and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends; provide practice in setting up trend logging and monitoring during training session.
- d. Every display screen, allowing time for questions.
- e. Use of keypad or plug-in laptop computer at the zone level.
- f. Use of remote access to the system via phone lines or networks.
- g. Setting up and changing an air terminal unit controller.
- h. Graphics generation.
- i. Point database entry and modifications.
- j. Understanding DDC field panel operating programming, when applicable.
- 3. Phase 3 Post-Occupancy: Six months after occupancy conduct minimum of 4 hours of training. Tailor training session to questions and topics solicited beforehand from Caesar Rodney School District. Also be prepared to address topics brought up and answer questions concerning operation of the system.
- G. Provide the services of manufacturer representatives to assist instructors where necessary.
- H. Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

# END OF SECTION

# SECTION 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

#### PART 1 GENERAL

### 1.01 SECTION INCLUDES

- A. Thermostats, Temperature Sensors.
- B. Automatic dampers.
- C. Damper operators.
- D. Miscellaneous accessories.

### 1.02 RELATED REQUIREMENTS

- A. Section 23 21 13 Hydronic Piping: Installation of control valves, flow switches, temperature sensor sockets, gage taps.
- B. Section 23 33 00 Air Duct Accessories: Installation of automatic dampers.
- C. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.
- D. Section 23 09 23 Direct-Digital Control System for HVAC.
- E. Section 23 09 93 Sequence of Operations for HVAC Controls.
- F. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

# 1.03 REFERENCE STANDARDS

- A. AMCA 500-D Laboratory Methods of Testing Dampers for Rating.
- B. ASME B16.22 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- C. ASTM B32 Standard Specification for Solder Metal.
- D. ASTM B88 Standard Specification for Seamless Copper Water Tube.
- E. ASTM D1693 Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
- F. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- G. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association.
- H. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems.

### 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.
- C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.
- D. Manufacturer's Instructions: Provide for all manufactured components.
- E. Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.
  - 1. Revise shop drawings to reflect actual installation and operating sequences.
- F. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.

- G. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Caesar Rodney School District s name and registered with manufacturer.
- H. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
  - 2. Extra Thermostats and Other Exposed Sensors: One of each type.

#### 1.05 QUALITY ASSURANCE

A. Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this work and licensed in Delaware.

#### 1.06 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a two year period after Substantial Completion.

#### PART 2 PRODUCTS

#### 2.01 EQUIPMENT - GENERAL

A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

#### 2.02 CONTROL PANELS

- A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face.
- B. NEMA 250, general purpose utility enclosures with enamelled finished face panel.
- C. Provide common keying for all panels.

#### 2.03 DAMPERS

- A. Performance: Test in accordance with AMCA 500-D.
- B. Frames: Galvanized steel, welded or riveted with corner reinforcement, minimum 12 gage.
- C. Blades: Galvanized steel, maximum blade size 8 inches wide, 48 inches long, minimum 22 gage, attached to minimum 1/2 inch shafts with set screws.
- D. Blade Seals: Synthetic elastomeric inflatable mechanically attached, field replaceable.
- E. Jamb Seals: Spring stainless steel.
- F. Shaft Bearings: Oil impregnated sintered bronze.
- G. Linkage Bearings: Oil impregnated sintered bronze.
- H. Leakage: Less than one percent based on approach velocity of 2000 ft/min and 4 inches wg.
- I. Maximum Pressure Differential: 6 inches wg.
- J. Temperature Limits: -40 to 200 degrees F.

#### 2.04 DAMPER OPERATORS

- A. General: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
  - 1. Provide sufficient number of operators to achieve unrestricted movement throughout damper range.
  - 2. Provide one operator for maximum 36 sq ft damper section.
- B. Electric Operators:

1. Spring return, adjustable stroke motor having oil immersed gear train, with auxiliary end switch.

# 2.05 INPUT/OUTPUT SENSORS

- A. Temperature Sensors:
  - 1. Sensor range shall provide a resolution of no worse than .4°F (unless noted otherwise).
  - 2. All wall-mounted temperature sensors shall be flat plate type sensors with no possible adjustment or display. VRF indoor unit controllers shall be installed above ceilings and remote, flat plate sensors shall be provided and installed in the space.
  - 3. Room temperature sensor shall be an element contained within a ventilated cover, suitable for wall mounting with digital output. Sensors located in conditioned areas shall be a flat plate sensor with no possible adjustment. ATC contractor shall coordinate requirements with the design engineer during the submittal process. Provide insulated base. Following sensing elements are acceptable:
    - a. Sensing element Platinum RTD, Thermistor, or integrated circuit, +/- 0.8°F accuracy at calibration point.
    - b. Units shall have no display or setpoint adjustment by the space occupant.
  - 4. Single point duct temperature sensor shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A. Sensor probe shall be 316 stainless steel.
    - a. Sensing element Platinum RTD, Thermistor, or integrated circuit, +/- 0.8°F accuracy at calibration point.
  - 5. Averaging duct temperature sensor shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide enough sensors to give one lineal foot of sensing element for each square foot of cooling coil face area. Temperature range as required for resolution indicated in paragraph A.
    - a. Sensing element Platinum RTD, Thermistor, or integrated circuit, +/- 0.8°F accuracy at calibration point.
  - 6. Liquid immersion temperature sensor shall include stainless steel thermowell, sensor and connection head for wiring connections.
    - a. Sensing element for chilled water applications Platinum RTD, Thermistor, or integrated circuit, +/- 0.8°F accuracy at calibration point. Temperature range shall be as required for resolution indicated in paragraph A.
    - Sensing element for non-chilled water applications Platinum RTD, +/- 0.2°F accuracy at calibration point. Temperature range shall be as required for resolution of no worse than 0.1°F.
- B. Humidity Sensors:
  - 1. Elements: Accurate within 5 percent full range with linear output.
  - 2. Room Sensors: With locking cover, span of 10 to 60 percent relative humidity.
  - 3. Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 100 percent relative humidity.
  - 4. Wall-mounted sensors shall be input devices only and shall not be equipped with any display or means for adjustment.
- C. Nitrogen Dioxide Sensors, for Single-Gang Electrical Box Mounting:
  - 1. General:
    - a. Provide gas platform, wired to the building controller, with replaceable sensor.
    - b. Input Power: Class 2; 15 30 VDC, plus/minus 20 percent, 50/60 Hz.
    - c. Relay Ratings: 1A/30VAC/DC, normally open.
    - d. Operating Temperature Range: Minus 4 degrees F to 122 degrees F.
    - e. Operating Humidity Range: 0 90 percent RH non-condensing.
  - 2. Sensor:

- a. Sensor Type: Electrochemical.
- b. Accuracy: Plus/minus 5 percent of range at 25 degrees F.
- c. Resolution: 0.1 ppm.
- d. Sensor Warranty: 2 years from manufacture date.
- e. Operating Temperature Range: Minus 4 degrees F to 122 degrees F.
- f. Operating Humidity Range: 0 to 90 percent RH non-condensing.
- D. Carbon Monoxide Sensors, for Single-Gang Electrical Box Mounting:
  - 1. General:
    - a. Provide gas platform, wired to the building controller, with replaceable sensor.
    - b. Input Power: Class 2; 15 30 VDC/24 VAC plus/minus 20 percent, 50/60 Hz.
    - c. Relay Ratings: 1A/30VAC/DC, normally open.
    - d. Operating Temperature Range: Minus 4 degrees F to 122 degrees F.
    - e. Operating Humidity Range: 0 90 percent RH non-condensing.
  - 2. Sensor:
    - a. Sensor Type: Electrochemical.
    - b. Accuracy: Plus/minus 5 percent of range.
    - c. Resolution: 1 ppm.
    - d. Sensor Warranty: 2 years from manufacture date.
    - e. Operating Temperature Range: Minus 4 degrees F to 122 degrees F.
    - f. Operating Humidity Range: 0 to 90 percent RH non-condensing.
- E. Static Pressure Sensors:
  - 1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.
  - 2. Temperature compensate with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F.
  - 3. Accuracy: One percent of full scale with repeatability 0.3 percent.
  - 4. Output: 0 5 vdc with power at 12 to 28 vdc.
- F. Equipment Operation Sensors:
  - 1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 5 inches wg.
  - 2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi.
  - 3. Status Inputs for Electric Motors: Current sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
- G. Damper Position Indication: Potentiometer mounted in enclosure with adjustable crank arm assembly connected to damper to transmit 0 100 percent damper travel.
- H. Carbon Dioxide Level Sensors:
  - 1. Wall or duct-mounted as required by control sequence or plans.
  - 2. Demand-control ventilation sensor for measuring and transmitting CO2 levels ranging from 0-2,000 ppm.
  - 3. Single-beam, dual-wavelength design with five-year stability for calibration..
  - 4. Proportional output, 4-20 mA signal.

#### 2.06 THERMOSTATS

- A. Line Voltage Thermostats:
  - 1. Integral manual On/Off/Auto selector switch, single or two pole as required.
  - 2. Dead band: Maximum 2 degrees F.
  - 3. Cover: Locking with set point adjustment, with thermometer.
  - 4. Rating: Motor load.
- B. Room Thermostat Accessories:
  - 1. Thermostat Covers: Brushed aluminum.

- 2. Insulating Bases: For thermostats located on exterior walls.
- C. Outdoor Reset Thermostat:
  - 1. Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable setpoint.
  - 2. Scale range: -10 to 70 degrees F.
- D. Immersion Thermostat:
  - 1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint and adjustable throttling range.
- E. Airstream Thermostats:
  - 1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint in middle of range and adjustable throttling range.
  - 2. Averaging service remote bulb element: 7.5 feet.
- F. Electric Low Limit Duct Thermostat:
  - 1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint,
  - 2. Bulb length: Minimum 20 feet.
  - 3. Provide one thermostat for every 20 sq ft of coil surface.
- G. Electric High Limit Duct Thermostat:
  - 1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above setpoint,
  - 2. Bulb length: Minimum 20 feet.
  - 3. Provide one thermostat for every 20 sq ft of coil surface.
- H. Fire Thermostats:
  - 1. UL labeled, factory set in accordance with NFPA 90A.
  - 2. Normally closed contacts, manual reset.
- I. Heating/Cooling Valve Top Thermostats:
  - 1. Proportional acting for proportional flow, molded rubber diaphragm, remote bulb liquid filled element, direct and reverse acting at differential pressure to 25 psig, cast housing with position indicator and adjusting knob.

### 2.07 TIME CLOCKS

A. Seven day programming switch timer with synchronous timing motor and seven day dial, continuously charged Ni-cad battery driven power failure 8 hour carry over and multiple switch trippers to control systems for minimum of two and maximum of eight signals per day with two normally open and two normally closed output switches.

### 2.08 TRANSMITTERS

- A. Pressure Transmitters:
  - 1. One pipe direct acting indicating type for gas, liquid, or steam service, range suitable for system, proportional electronic output.
- B. Temperature Transmitters:
  - One pipe, directly proportional output signal to measured variable, linearity within plus or minus 1/2 percent of range for 200 degree F span and plus or minus 1 percent for 50 degree F span, with 50 degrees F temperature range, compensated bulb, averaging capillary, or rod and tube operation on 20 psig input pressure and 3 to 15 psig output.
- C. Humidity Transmitters:
  - 1. One pipe, directly proportioned output signal to measured variable, linearity within plus or minus 1 percent for 70 percent relative humidity span, capable of withstanding 95 percent relative humidity without loss of calibration.

### PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that systems are ready to receive work.
- C. Beginning of installation means installer accepts existing conditions.
- D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.
- E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- F. Ensure installation of components is complementary to installation of similar components.
- G. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

#### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Wall mounted sensors shall be mounted 48" above finished floor.
- C. VRF indoor units shall be provided with unit controllers installed above ceilings at the unit and remote, flat plate sensors with no adjustment or display shall be extended and installed in the space.
- D. Check and verify location of thermostats with plans and room details before installation. Locate 48 inches above floor. Align with lighting switches, CO2 sensors, and humidistats. Refer to Section 26 27 26.
- E. Mount freeze protection thermostats using flanges and element holders.
- F. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
- G. Provide separable sockets for liquids and flanges for air bulb elements.
- H. Provide guards on thermostats in gymnasiums, corridors, weight rooms, locker rooms, entrances, mechanical rooms, and utility rooms.
- I. Provide valves with position indicators and with pilot positioners where sequenced with other controls.
- J. Provide mixing dampers of opposed blade construction arranged to mix streams. Provide separate minimum outside air damper section adjacent to return air dampers with separate damper motor.
- K. Provide isolation (two position) dampers of parallel blade construction.
- L. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
- M. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
- N. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
- O. Provide conduit and electrical wiring in accordance with Section 26 27 17. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

#### 3.03 MAINTENANCE

- A. See Section 01 70 00 Execution Requirements, for additional requirements relating to maintenance service.
- B. Provide service and maintenance of control system for two years from Date of Substantial Completion.
- C. Provide complete service of controls systems, including call backs, and submit written report of each service call.
- D. In addition to normal service calls, make minimum of 4 complete normal inspections of approximately 4 hours duration to inspect, calibrate, and adjust controls.

#### END OF SECTION

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# SECTION 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

### PART 1 GENERAL

### **1.01 SECTION INCLUDES**

- A. System Description
- B. Operator Interface
- C. Controllers
- D. Power Supplies and Line Filtering
- E. System Software
- F. Controller Software
- G. HVAC Control Programs
- H. Control equipment.
- I. Software.

### 1.02 RELATED REQUIREMENTS

- A. Section 28 31 00 Fire Detection and Alarm.
- B. Section 23 09 13 Instrumentation and Control Devices for HVAC.
- C. Section 23 09 93 Sequence of Operations for HVAC Controls.
- D. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.
- E. Section 27 52 23.50 Educational Intercommunications and Programs Education For Sustainability Systems

### 1.03 REFERENCE STANDARDS

- A. ASHRAE Std 135 BACnet A Data Communication Protocol for Building Automation and Control Networks.
- B. NFPA 70 National Electrical Code.

### 1.04 SYSTEM DESCRIPTION

- A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units connected to the existing Building Automation System.
- B. The BAS contractor shall provide all interconnecting wiring, interfaces, and programming required to completely integrate the VRF system into the building automation system and achieve full read / write capability of all VRF points from the BAS operator workstation as available at the VRF control workstation. The BAS contractor is responsible for achieving the specified sequences of operations.
- C. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
- D. Include computer software and all hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
- E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment, power transformers and electrical feeds, and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
- F. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

- G. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.
- H. The existing BAS system is to be modified to include the addition of ATC devices, sensors, and controller hardware & software as required to accomplish the sequences of operations in 23 09 93.

### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data for each system component and software module.
- C. Shop Drawings:
  - 1. Indicate trunk cable schematic showing programmable control unit locations, and trunk data conductors.
  - 2. List connected data points, including connected control unit and input device.
  - Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration diskette containing graphics.
  - 4. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
  - 5. Indicate description and sequence of operation of operating, user, and application software.
- D. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.
- E. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.
  - 1. Revise shop drawings to reflect actual installation and operating sequences.
  - 2. Include submittals data in final "Record Documents" form.
- F. Operation and Maintenance Data:
  - 1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
  - 2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
  - 3. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
- G. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Caesar Rodney School District s name and registered with manufacturer.

#### 1.06 QUALITY ASSURANCE

- A. Perform work in accordance with NFPA 70.
- B. Design system software under direct supervision of a Professional Engineer experienced in design of this Work and licensed at Delaware.
- C. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum 10 years documented experience.
- D. Installer Qualifications: Company specializing in performing the work of this section 5 years documented experience approved by manufacturer.
- E. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

### 1.07 PRE-INSTALLATION MEETING

A. Convene one week before starting work of this Section.

B. Require attendance of parties directly affecting the work of this Section.

### 1.08 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a two year period after Substantial Completion.
- C. Provide five year manufacturer's warranty for field programmable micro-processor based units.

#### 1.09 MAINTENANCE SERVICE

- A. Provide service and maintenance of energy management and control systems for one years from Date of Substantial Completion.
- B. Provide four complete inspections per year, two in each season, to inspect, calibrate, and adjust controls as required, and submit written reports.
- C. Provide complete service of systems, including call backs. Make minimum of 4 complete normal inspections of approximately 4 hours duration in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports.

#### 1.10 EXTRA MATERIALS

A. See Section 01 60 00 - Product Requirements, for additional provisions.

#### 1.11 PROTECTION OF SOFTWARE RIGHTS

- A. Prior to delivery of software, the Caesar Rodney School District and the party providing the software will enter into a software license agreement with provisions for the following:
  - 1. Limiting use of software to equipment provided under these specifications.
  - 2. Limiting copying.
  - 3. Preserving confidentiality.
  - 4. Prohibiting transfer to a third party.

#### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Johnson Controls, Inc: www.johnsoncontrols.com.
- B. Substitutions: Not Permitted.

#### 2.02 PRODUCT DESCRIPTION

- A. Web-based automatic temperature control field monitoring and control system using field programmable micro-processor based units for seamless integration into the existing building automation system..
- B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
- C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN) including all cabling, raceways, power transformers and electrical circuiting, sensors, control devices, actuators, etc. to provide a complete infrastructure for the BAS.
- D. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 23 09 13.
- E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
- F. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

### 2.03 OPERATOR INTERFACE

- A. PC Based Work Station:
  - 1. Contractor shall install and configure a software package on the existing workstation located on site.
- B. Workstation, controllers, and control backbone to communicate using BACnet protocol and addressing.
- C. BACnet protocol to comply with ASHRAE Std 135.

### 2.04 CONTROLLERS

- A. BUILDING CONTROLLERS
  - 1. General:
    - a. Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
    - b. Provide sufficient memory to support controller's operating system, database, and programming requirements.
    - c. Share data between networked controllers.
    - d. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
    - e. Utilize real-time clock for scheduling.
    - f. Continuously check processor status and memory circuits for abnormal operation.
    - g. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
    - h. Communication with other network devices to be based on assigned protocol.
  - 2. Communication:
    - a. Controller to reside on a BACnet network using ISO 8802-3 (ETHERNET) Data Link/Physical layer protocol.
    - b. Perform routing when connected to a network of custom application and application specific controllers.
    - c. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
  - 3. Anticipated Environmental Ambient Conditions:
    - a. Outdoors and/or in Wet Ambient Conditions:
      - 1) Mount within waterproof enclosures.
      - 2) Rated for operation at 40 to 150 degrees F.
    - b. Conditioned Space:
      - 1) Mount within dustproof enclosures.
      - 2) Rated for operation at 32 to 120 degrees F.
  - 4. Provisions for Serviceability:
    - a. Diagnostic LEDs for power, communication, and processor.
    - b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
  - 5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
  - 6. Power and Noise Immunity:
    - a. Maintain operation at 90 to 110 percent of nominal voltage rating.
    - b. Perform orderly shutdown below 80 percent of nominal voltage.
    - c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.
- B. INPUT/OUTPUT INTERFACE

- 1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.
- 2. All Input/Output Points:
  - a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
  - b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.
- 3. Binary Inputs:
  - a. Allow monitoring of On/Off signals from remote devices.
  - b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
  - c. Sense dry contact closure with power provided only by the controller.
- 4. Pulse Accumulation Input Objects: Conform to all requirements of binary input objects and accept up to 10 pulses per second.
- 5. Analog Inputs:
  - a. Allow for monitoring of low voltage 0 to 10 VDC, 4 to 20 mA current, or resistance signals (thermistor, RTD).
  - b. Compatible with and field configurable to commonly available sensing devices.
- 6. Binary Outputs:
  - a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
  - b. Outputs provided with three position (On/Off/Auto) override switches.
  - c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.
- 7. Analog Outputs:
  - a. Monitoring signal provides a 0 to 10 VDC or a 4 to 20 mA output signal for end device control.
  - b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
  - c. Drift to not exceed 0.4 percent of range per year.
- 8. Tri State Outputs:
  - a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
  - b. Control algorithms run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
- 9. System Object Capacity:
  - a. System size to be expandable to twice the number of input output objects required by providing additional controllers, including associated devices and wiring.
  - b. Hardware additions or software revisions for the installed operator interfaces are not to be required for future, system expansions.

# 2.05 POWER SUPPLIES AND LINE FILTERING

- A. Power Supplies:
  - 1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.

a. Contractor to provide necessary transformers for all BAS devices, controllers, etc. Coordinate with electrical contractor for necessary circuiting.

- 2. Limit connected loads to 80 percent of rated capacity.
- 3. Match DC power supply to current output and voltage requirements.

- 4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
- 5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
- 6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
- 7. Operational Ambient Conditions: 32 to 120 degrees F.
- 8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
- 9. Line voltage units UL recognized and CSA approved.
- B. Power Line Filtering:
  - 1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
  - 2. Minimum surge protection attributes:
    - a. Dielectric strength of 1000 volts minimum.
    - b. Response time of 10 nanoseconds or less.
    - c. Transverse mode noise attenuation of 65 dB or greater.
    - d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

#### 2.06 CONTROL UNITS

- A. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.
- B. Battery Backup: For minimum of 48 hours for complete system including RAM without interruption, with automatic battery charger.
- C. Control Units Functions:
  - 1. Monitor or control each input/output point.
  - 2. Completely independent with hardware clock/calendar and software to maintain control independently.
  - 3. Acquire, process, and transfer information to operator station or other control units on network.
  - 4. Accept, process, and execute commands from other control unit's or devices or operator stations.
  - 5. Access both data base and control functions simultaneously.
  - 6. Record, evaluate, and report changes of state or value that occur among associated points. Continue to perform associated control functions regardless of status of network.
  - 7. Perform in stand-alone mode:
    - a. Start/stop.
    - b. Duty cycling.
    - c. Automatic Temperature Control.
    - d. Demand control via a sliding window, predictive algorithm.
    - e. Event initiated control.
    - f. Calculated point.
    - g. Scanning and alarm processing.
    - h. Full direct digital control.
    - i. Trend logging.
    - j. Global communications.
    - k. Maintenance scheduling.
- D. Global Communications:
  - 1. Broadcast point data onto network, making that information available to all other system control units.
  - 2. Transmit any or all input/output points onto network for use by other control units and utilize data from other control units.

- E. Input/Output Capability:
  - 1. Discrete/digital input (contact status).
  - 2. Discrete/digital output.
  - 3. Analog input.
  - 4. Analog output.
  - 5. Pulse input (5 pulses/second).
  - 6. Pulse output (0-655 seconds in duration with 0.01 second resolution).
- F. Monitor, control, or address data points. Mix shall include analog inputs, analog outputs, pulse inputs, pulse outputs and discrete inputs/outputs, as required. Install control unit's with minimum 30 percent spare capacity.
- G. Point Scanning: Set scan or execution speed of each point to operator selected time from 1 to 250 seconds.
- H. Upload/Download Capability: Download from or upload to operator station. Upload/Download time for entire control unit database maximum 10 seconds on hard wired LAN, or 60 seconds over voice grade phone lines.
- I. Test Mode Operation: Place input/output points in test mode to allow testing and developing of control algorithms on line without disrupting field hardware and controlled environment. In test mode:
  - 1. Inhibit scanning and calculation of input points. Issue manual control to input points (set analog or digital input point to operator determined test value) from work station.
  - 2. Control output points but change only data base state or value; leave external field hardware unchanged.
  - 3. Enable control actions on output points but change only data base state or value.
- J. Local display and adjustment panel: Portable control unit, containing digital display, and numerical keyboard. Display and adjust:
  - 1. Input/output point information and status.
  - 2. Controller set points.
  - 3. Controller tuning constants.
  - 4. Program execution times.
  - 5. High and low limit values.
  - 6. Limit differential.
  - 7. Set/display date and time.
  - 8. Control outputs connected to the network.
  - 9. Automatic control outputs.
  - 10. Perform control unit diagnostic testing.
  - 11. Points in "Test" mode.

### 2.07 LOCAL AREA NETWORK (LAN)

- A. Provide communication between control units over local area network (LAN).
- B. LAN Capacity: Not less than 100 stations or nodes.
- C. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.
- D. LAN Data Speed: Minimum 19.2 Kb.
- E. Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over telephone lines utilizing modems.
- F. Transmission Median: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.
- G. Network Support: Time for global point to be received by any station, shall be less than 3 seconds. Provide automatic reconfiguration if any station is added or lost. If transmission cable

is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

### 2.08 SYSTEM SOFTWARE

- A. Operating System:
  - 1. Concurrent, multi-tasking capability.
    - a. Common Software Applications Supported: Microsoft Excel.
  - 2. System Graphics:
    - a. Allow up to 12 graphic screens, simultaneously displayed for comparison and monitoring of system status.
    - b. Animation displayed by shifting image files based on object status.
    - c. Provide method for operator with password to perform the following:
      - 1) Move between, change size, and change location of graphic displays.
      - 2) Modify on-line.
      - 3) Add, delete, or change dynamic objects consisting of:
        - (a) Analog and binary values.
        - (b) Dynamic text.
        - (c) Static text.
        - (d) Animation files.
  - 3. Custom Graphics Generation Package:
    - a. Create, modify, and save graphic files and visio format graphics in PCX formats.
    - b. HTML graphics to support web browser compatible formats.
    - c. Capture or convert graphics from AutoCAD.
  - 4. Standard HVAC Graphics Library including, but not limited to:
    - a. HVAC Equipment:
      - 1) Air Handlers.
      - 2) Terminal HVAC Units.
      - 3) Energy Recovery Ventilators with Duct-Mounted Heating Coils
      - 4) Variable Refrigerant Flow (VRF) System -- Including indoor units, outdoor units, multi-port branch selector boxes, and interconnecting refrigerant piping.
    - b. Ancillary Equipment:
      - 1) Fans.
      - 2) Pumps.
      - 3) Coils.
      - 4) Valves.
      - 5) Piping.
      - 6) Dampers.
      - 7) Ductwork.
- B. Workstation System Applications:
  - 1. Automatic System Database Save and Restore Functions:
    - a. Current database copy of each Building Controller is automatically stored on hard disk.
    - b. Automatic update occurs upon change in any system panel.
    - c. In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.
  - 2. Manual System Database Save and Restore Functions by Operator with Password Clearance:
    - a. Save database from any system panel.
    - b. Clear a panel database.
    - c. Initiate a download of a specified database to any system panel.

- 3. Software provided allows system configuration and future changes or additions by operators under proper password protection.
- 4. On-line Help:
  - a. Context-sensitive system assists operator in operation and editing.
  - b. Available for all applications.
  - c. Relevant screen data provided for particular screen display.
  - d. Additional help available via hypertext.
- 5. Security:
  - a. Operator log-on requires user name and password to view, edit, add, or delete data.
  - b. System security selectable for each operator.
  - c. System supervisor sets passwords and security levels for all other operators.
  - d. Operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
  - e. Automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
  - f. All system security data stored in encrypted format.
- 6. System Diagnostics:
  - a. Operations Automatically Monitored:
    - 1) Workstations.
    - 2) Printers.
    - 3) Modems.
    - 4) Network connections.
    - 5) Building management panels.
    - 6) Controllers.
  - b. Device failure is annunciated to the operator.
- 7. Alarm Processing:
  - a. All system objects are configurable to "alarm in" and "alarm out" of normal state.
  - b. Configurable Objects:
    - 1) Alarm limits.
    - 2) Alarm limit differentials.
    - 3) States.
    - 4) Reactions for each object.
- 8. Alarm Messages:
  - a. Descriptor: English language.
  - b. Recognizable Features:
    - 1) Source.
    - 2) Location.
    - 3) Nature.
- 9. Configurable Alarm Reactions by Workstation and Time of Day:
  - a. Logging.
  - b. Printing.
  - c. Starting programs.
  - d. Displaying messages.
  - e. Dialing out to remote locations.
  - f. Paging.
  - g. Providing audible annunciation.
  - h. Displaying specific system graphics.
- 10. Custom Trend Logs:
  - a. Definable for any data object in the system including interval, start time, and stop time.
  - b. Trend Data:

- 1) Sampled and stored on the building controller panel.
- 2) Archivable on hard disk.
- 3) Retrievable for use in reports, spreadsheets and standard database programs.
- 4) Archival on LAN accessible storage media including hard disk, tape, Raid array drive, and virtual cloud environment.
- 5) Protected and encrypted format to prevent manipulation, or editing of historical data and event logs.
- 11. Alarm and Event Log:
  - a. View all system alarms and change of states from any system location.
  - b. Events listed chronologically.
  - c. Operator with proper security acknowledges and clears alarms.
  - d. Alarms not cleared by operator are archived to the workstation hard disk.
- 12. Object, Property Status and Control:
  - a. Provide a method to view, edit if applicable, the status of any object and property in the system.
  - b. Status Available by the Following Methods:
    - 1) Menu.
    - 2) Graphics.
    - 3) Custom Programs.
- 13. Reports and Logs:
  - a. Reporting Package:
    - 1) Allows operator to select, modify, or create reports.
    - 2) Definable as to data content, format, interval, and date.
    - 3) Archivable to hard disk.
  - b. Real-time logs available by type or status such as alarm, lockout, normal, etc.
  - c. Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
  - d. Set to be printed on operator command or specific time(s).
- 14. Reports:
  - a. Standard:
    - 1) Objects with current values.
    - 2) Current alarms not locked out.
    - 3) Disabled and overridden objects, points and SNVTs.
    - 4) Objects in manual or automatic alarm lockout.
    - 5) Objects in alarm lockout currently in alarm.
    - 6) Logs:
      - (a) Alarm History.
      - (b) System messages.
      - (c) System events.
      - (d) Trends.
  - b. Custom:
    - 1) Daily.
    - 2) Weekly.
    - 3) Monthly.
    - 4) Annual.
    - 5) Time and date stamped.
    - 6) Title.
    - 7) Facility name.
  - c. Tenant Override:
    - 1) Monthly report showing total, requested, after-hours HVAC and lighting services on a daily basis for each tenant.
- 2) Annual report showing override usage on a monthly basis.
- d. Electrical, Fuel, and Weather:
  - 1) Electrical Meter(s):
    - (a) Monthly showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
    - (b) Annual summary showing monthly electrical consumption and peak demand with time and date stamp for each meter.
  - 2) Fuel Meter(s):
    - (a) Monthly showing daily natural gas consumption for each meter.
    - (b) Annual summary showing monthly consumption for each meter.
  - 3) Weather:
    - (a) Monthly showing minimum, maximum, average outdoor air temperature and heating/cooling degree-days for the month.
- C. Workstation Applications Editors:
  - 1. Provide editing software for all system applications at the PC workstation.
  - 2. Downloaded application is executed at controller panel.
  - 3. Full screen editor for each application allows operator to view and change:
    - a. Configuration.
    - b. Name.
    - c. Control parameters.
    - d. Set-points.
  - 4. Scheduling:
    - a. Monthly calendar indicates schedules, holidays, and exceptions.
    - b. Allows several related objects to be scheduled and copied to other objects or dates.
    - c. Start and stop times adjustable from master schedule.
  - 5. Custom Application Programming:
    - a. Create, modify, debug, edit, compile, and download custom application programming during operation and without disruption of all other system applications.
    - b. Programming Features:
      - 1) English oriented language, based on BASIC, FORTRAN, C, or PASCAL syntax allowing for free form programming.
      - 2) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.
      - 3) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.
      - 4) Allows the development of independently, executing, program modules designed to enable and disable other modules.
      - 5) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.
      - Support for conditional statements (IF/THEN/ELSE/ELSE-F) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
      - 7) Support for floating-point arithmetic utilizing plus, minus, divide, times, square root operators; including absolute value; minimum/maximum value from a list of values for mathematical functions.
      - 8) Language consisting of resettable, predefined, variables representing time of day, day of the week, month of the year, date; and elapsed time in seconds, minutes, hours, and days where the variable values cab be used in IF/THEN comparisons, calculations, programming statement logic, etc.

9) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

# 2.09 CONTROLLER SOFTWARE

- A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.
- B. System Security:
  - 1. User access secured via user passwords and user names.
  - 2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
  - 3. User Log On/Log Off attempts are recorded.
  - 4. Automatic Log Off occurs following the last keystroke after a user defined delay time.
- C. Object or Object Group Scheduling:
  - 1. Weekly Schedules Based on Separate, Daily Schedules:
    - a. Include start, stop, optimal stop, and night economizer.
    - b. 10 events maximum per schedule.
    - c. Start/stop times adjustable for each group object.
- D. Provide standard application for equipment coordination and grouping based on function and location to be used for scheduling and other applications.
- E. Alarms:
  - 1. Binary object is set to alarm based on the operator specified state.
  - 2. Analog object to have high/low alarm limits.
  - 3. All alarming is capable of being automatically and manually disabled.
  - 4. Alarm Reporting:
    - a. Operator determines action to be taken for alarm event.
    - b. Alarms to be routed to appropriate workstation.
    - c. Reporting Options:
- F. Demand Limiting:
  - 1. Building power consumption monitored from signals generated by a pulse generator, mounted at the building power meter.
  - 2. Demand limit controlled via load shedding or load restoration in a predetermined and predictive manner.
  - 3. Demand Reduction Methods:
    - a. Supply air temperature reset.
    - b. Space temperature set-point reset.
  - 4. Relevant variables that influence demand limiting control are based on the power company methodology for computing demand charges.
  - 5. Operator On-Line Changes Allowed:
    - a. Addition and deletion of loads controlled.
    - b. Changes in demand intervals.
    - c. Changes in demand limit for meter(s).
    - d. Maximum equipment shutoff time.
    - e. Minimum equipment shutoff time.
    - f. Select rotational or sequential shedding and restoring.
    - g. Shed/restore priority.
  - 6. Information and Reports available Hourly, Daily, and Monthly:
    - a. Total electric consumption.
    - b. Peak demand.
    - c. Date and time of peak demand.

- d. Daily peak demand.
- G. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.
- H. Sequencing: Application software based upon specified sequences of operation in Section 23 09 93.
- I. PID Control Characteristics:
  - 1. Direct or reverse action.
  - 2. Anti-windup.
  - 3. Calculated, time-varying, analog value, positions an output or stages a series of outputs.
  - 4. User selectable controlled variable, set-point, and PED gains.
- J. Staggered Start Application:
  - 1. Prevents all controlled equipment from simultaneously restarting after power outage.
  - 2. Order of equipment startup is user selectable.
- K. Energy Calculations:
  - 1. Accumulated instantaneous power or flow rates are converted to energy use data.
  - 2. Algorithm calculates a rolling average and allows window of time to be user specified in minute intervals.
  - 3. Algorithm calculates a fixed window average with a digital input signal from a utility meter defining the start of the window period that in turn synchronizes the fixed-window average with that used by the power company.
- L. Anti-Short Cycling:
  - 1. All binary output objects protected from short-cycling.
  - 2. Allows minimum on-time and off-time to be selected.
- M. On-Off Control with Differential:
  - 1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
  - 2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.
- N. Run-Time Totalization:
  - 1. Totalize run-times for all binary input objects.
  - 2. Provides operator with capability to assign high run-time alarm.

## 2.10 OPERATING SYSTEM SOFTWARE

- A. Fully web-based / web hosted software package compatible with the Owner's existing campus-wide ssytem.
  - 1. CONTRACTOR SHALL INCLUDE ALL LICENSING FEES AND APPLICABLE UPGRADE FEES TO THE EXISTING BUILDING AUTOMATION SYSTEM TO ALLOW FOR SEAMLESS INTEGRATION OF THE NEW COMPONENTS.
- B. Input/Output Capability From Operator Station:
  - 1. Request display of current values or status in tabular or graphic format.
  - 2. Command selected equipment to specified state.
  - 3. Initiate logs and reports.
  - 4. Change analog limits.
  - 5. Add, delete, or change points within each control unit or application routine.
  - 6. Change point input/output descriptors, status, alarm descriptors, and engineering unit descriptors.
  - 7. Add new control units to system.
  - 8. Modify and set up maintenance scheduling parameters.
  - 9. Develop, modify, delete or display full range of color graphic displays.
  - 10. Automatically archive select data even when running third party software.

- 11. Provide capability to sort and extract data from archived files and to generate custom reports.
- 12. Support two printer operations.
  - a. Alarm printer: Print alarms, operator acknowledgements, action messages, system alarms, operator sign-on and sign-off.
  - b. Data printer: Print reports, page prints, and data base prints.
- 13. Select daily, weekly or monthly as scheduled frequency to synchronize time and date in digital control units. Accommodate daylight savings time adjustments.
- 14. Print selected control unit data base.
- C. Operator System Access: Via software password with minimum 30 access levels at work station and minimum 3 access levels at each control unit.
- D. Data Base Creation and Support: Changes shall utilize standard procedures. Control unit shall automatically check work station data base files upon connection and verify data base match. Minimum capability shall include:
  - 1. Add and delete points.
  - 2. Modify any point parameter.
  - 3. Change, add, or delete English language descriptors.
  - 4. Add, modify, or delete alarm limits.
  - 5. Add, modify, or delete points in start/stop programs, trend logs, etc.
  - 6. Create custom relationship between points.
  - 7. Create or modify DDC loops and parameters.
  - 8. Create or modify override parameters.
  - 9. Add, modify, and delete any applications program.
  - 10. Add, delete, develop, or modify dynamic color graphic displays.
- E. Dynamic Color Graphic Displays:
  - 1. Utilizes custom symbols or system supported library of symbols.
  - 2. Sixteen (16) colors.
  - 3. Sixty (60) outputs of real time, live dynamic data per graphic.
  - 4. Dynamic graphic data.
  - 5. 1,000 separate graphic pages.
  - 6. Modify graphic screen refresh rate between 1 and 60 seconds.
- F. Operator Station:
  - 1. Accept data from LAN as needed without scanning entire network for updated point data.
  - 2. Interrogate LAN for updated point data when requested.
  - 3. Allow operator command of devices.
  - 4. Allow operator to place specific control units in or out of service.
  - 5. Allow parameter editing of control units.
  - 6. Store duplicate data base for every control unit and allow down loading while system is on line.
  - 7. Control or modify specific programs.
  - 8. Develop, store and modify dynamic color graphics.
  - 9. Provide data archiving of assigned points and support overlay graphing of this data utilizing up to four (4) variables.
- G. Alarm Processing:
  - 1. Off normal condition: Cause alarm and appropriate message, including time, system, point descriptor, and alarm condition. Select alarm state/value and which alarms shall cause automatic dial-out.
  - 2. Critical alarm or change-of-state: Display message, stored on disk for review and sort, or print.

- 3. Print on line changeable message, up to 100 characters in length, for each alarm point specified.
- 4. Display alarm reports on video. Display multiple alarms in order of occurrence.
- 5. Define time delay for equipment start-up or shutdown.
- 6. Allow unique routing of specific alarms.
- 7. Operator specifies if alarm requires acknowledgement.
- 8. Continue to indicate unacknowledged alarms after return to normal.
- 9. Alarm notification:
  - a. Automatic print.
  - b. Display indicating alarm condition.
  - c. Selectable audible alarm indication.
- H. Event Processing: Automatically initiate commands, user defined messages, take specific control actions or change control strategy and application programs resulting from event condition. Event condition may be value crossing operator defined limit, change-of-state, specified state, or alarm occurrence or return to normal.
- I. Automatic Restart: Automatically restart field equipment on restoration of power. Provide time delay between individual equipment restart and time of day start/stop.
- J. Messages:
  - 1. Automatically display or print user-defined message subsequent to occurrence of selected events.
  - 2. Compose, change, or delete any message.
  - 3. Display or log any message at any time.
  - 4. Assign any message to any event.
- K. Reports:
  - 1. Manually requested with time and date.
  - 2. Long term data archiving to hard disk.
  - 3. Automatic directives to download to transportable media such as floppy diskettes for storage.
  - 4. Data selection methods to include data base search and manipulation.
  - 5. Data extraction with mathematical manipulation.
  - 6. Data reports shall allow development of XY curve plotting, tabular reports (both statistical and summary), and multi-point timed based plots with not less than four (4) variables displayed.
  - 7. Generating reports either normally at operator direction, or automatically under work station direction.
  - 8. Reports may either manually displayed or printed, or may be printed automatically on daily, weekly, monthly, yearly or scheduled basis.
  - 9. Include capability for statistical data manipulation and extraction.
  - 10. Provide capability to generate four types of reports: Statistical detail reports, summary reports, trend graphic plots, x-y graphic plots.
- L. Parameter Save/Restore: Store most current operating system, parameter changes, and modifications on disk or diskette.
- M. Data Collection:
  - 1. Automatically collect and store in disk files.
  - 2. Daily electrical energy consumption, peak demand, and time of peak demand for up to electrical meters over 2 year period.
  - 3. Daily consumption for up to 30 meters over a 2 year period.
  - 4. Daily billable electrical energy consumption and time for up to 1024 zones over a 10 year period.
  - 5. Provide archiving of stored data for use with system supplied custom reports.

- N. Graphic Display: Support graphic development on work station with software features:
  - 1. Page linking.
  - 2. Generate, store, and retrieve library symbols.
  - 3. Single or double height characters.
  - 4. Sixty (60) dynamic points of data per graphic page.
  - 5. Pixel level resolution.
  - 6. Animated graphics for discrete points.
  - 7. Analog bar graphs.
  - 8. Display real time value of each input or output line diagram fashion.
- O. Maintenance Management:
  - 1. Run time monitoring, per point.
  - 2. Maintenance scheduling targets with automatic annunciation, scheduling and shutdown.
  - 3. Equipment safety targets.
  - 4. Display of maintenance material and estimated labor.
  - 5. Target point reset, per point.
- P. Advisories:
  - 1. Summary which contains status of points in locked out condition.
  - 2. Continuous operational or not operational report of interrogation of system hardware and programmable control units for failure.
  - 3. Report of power failure detection, time and date.
  - 4. Report of communication failure with operator device, field interface unit, point, programmable control unit.

# 2.11 LOAD CONTROL PROGRAMS

- A. General: Support inch-pounds and SI (metric) units of measurement.
- B. Demand Limiting:
  - 1. Monitor total power consumption per power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.
  - 2. Input: Pulse count from incoming power meter connected to pulse accumulator in control unit.
  - 3. Forecast demand (kW): Predicted by sliding window method.
  - 4. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.
  - 5. Demand Target: Minimum of 3 per demand meter; change targets based upon (1) time, (2) status of pre-selected points, or (3) temperature.
  - 6. Load: Assign load shed priority, minimum "ON" time and maximum "OFF" time.
  - 7. Limits: Include control band (upper and lower limits).
  - 8. Output advisory if loads are not available to satisfy required shed amount, advise shed requirements and requiring operator acknowledgement.
- C. Duty Cycling:
  - 1. Periodically stop and start loads, based on space temperature, and according to various On/Off patterns.
  - 2. Modify off portion of cycle based on operator specified comfort parameters. Maintain total cycle time by increasing on portion of cycle by same amount that off portion is reduced.
  - 3. Set and modify following parameters for each individual load.
    - a. Minimum and maximum Off time.
    - b. On/Off time in one minute increments.
    - c. Time period from beginning of interval until load can be cycled.
    - d. Manually override the DCC program and place a load in an On or Off state.
    - e. Cooling Target Temperature and Differential.

- f. Heating Target Temperature and Differential.
- g. Cycle off adjustment.
- D. Automatic Time Scheduling:
  - 1. Self-contained programs for automatic start/stop/scheduling of building loads.
  - 2. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary day schedules.
  - 3. Special days schedule shall support up to 30 unique date/duration combinations.
  - 4. Any number of loads assigned to any time program; each load can have individual time program.
  - 5. Each load assigned at least 16 control actions per day with 1 minute resolution.
  - 6. Time schedule operations may be:
    - a. Start.
    - b. Optimized Start.
    - c. Stop.
    - d. Optimized Stop.
    - e. Cycle.
    - f. Optimized Cycle.
  - 7. Minimum of 30 holiday periods up to 100 days in length may be specified for the year.
  - 8. Create temporary schedules.
  - 9. Broadcast temporary "special day" date and duration.
- E. Start/Stop Time Optimization:
  - 1. Perform optimized start/stop as function of outside conditions, inside conditions, or both.
  - 2. Adaptive and self-tuning, adjusting to changing conditions unattended.
  - 3. For each point under control, establish and modify:
    - a. Occupancy period.
    - b. Desired temperature at beginning of occupancy period.
    - c. Desired temperature at end of occupancy period.
- F. Night Setback/Setup Program: Reduce heating space temperature setpoint or raise cooling space temperature setpoint during unoccupied hours; in conjunction with scheduled start/stop and optimum start/stop programs.
- G. Calculated Points: Define calculations and totalization computed from monitored points (analog/digital points), constants, or other calculated points.
  - 1. Employ arithmetic, algebraic, Boolean, and special function operations.
  - 2. Treat calculated values like any other analog value, use for any function that a "hard wired point" might be used.
- H. Event Initiated Programming: Event may be initiated by any data point, causing series of controls in a sequence.
  - 1. Define time interval between each control action between 0 to 3600 seconds.
  - 2. Output may be analog value.
  - 3. Provide for "skip" logic.
  - 4. Verify completion of one action before proceeding to next. If not verified, program shall be able to skip to next action.
- I. Direct Digital Control: Each control unit shall provide Direct Digital Control software so that the operator may customize control strategies and sequences of operation by defining the appropriate control loop algorithms and choosing the optimum loop parameters.
  - 1. Control loops: Defined using "modules" that are analogous to standard control devices.
  - 2. Output: Paired or individual digital outputs for pulse-width modulation, and analog outputs, as required.
  - 3. Firmware:
    - a. PID with analog or pulse-width modulation output.

- b. Floating control with pulse-width modulated outputs.
- c. Two-position control.
- d. Primary and secondary reset schedule selector.
- e. Hi/Lo signal selector.
- f. Single pole double throw relay.
- g. Single pole double throw time delay relay with delay before break, delay before make and interval time capabilities.
- 4. Direct Digital Control loops: Downloaded upon creation or on operator request. On sensor failure, program shall execute user defined failsafe output.
- 5. Display: Value or state of each of the lines which interconnect DDC modules.
- J. Fine Tuning Direct Digital Control PID or floating loops:
  - 1. Display information:
    - a. Control loop being tuned
    - b. Input (process) variable
    - c. Output (control) variable
    - d. Setpoint of loop
    - e. Proportional band
    - f. Integral (reset) Interval
    - g. Derivative (rate) Interval
  - 2. Display format: Graphic, with automatic scaling; with input and output variable superimposed on graph of "time" vs "variable".
- K. Trend logging:
  - 1. Each control unit will store samples of control unit's data points.
  - 2. Update file continuously at discretely assignable intervals.
  - 3. Automatically initiate upload request and then store data on hard disk.
  - 4. Time synchronize sampling at operator specified times and intervals with sample resolution of one minute.
  - 5. Co-ordinate sampling with on/off state of specified point.
  - 6. Display trend samples on work station in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time vs data.

## 2.12 HVAC CONTROL PROGRAMS

- A. General:
  - 1. Support Inch-pounds and SI (metric) units of measurement.
  - 2. Identify each HVAC Control system.
- B. Optimal Run Time:
  - 1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.
  - 2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.
  - 3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
  - 4. Use outside air temperature to determine early shut down with ventilation override.
  - 5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.
  - 6. Operator commands:
    - a. Define term schedule
    - b. Add/delete fan status point.
    - c. Add/delete outside air temperature point.
    - d. Add/delete mass temperature point.
    - e. Define heating/cooling parameters.

- f. Define mass sensor heating/cooling parameters.
- g. Lock/unlock program.
- h. Request optimal run time control summary.
- i. Request optimal run time mass temperature summary.
- j. Request HVAC point summary.
- k. Request HVAC saving profile summary.
- 7. Control Summary:
  - a. HVAC Control system begin/end status.
  - b. Optimal run time lock/unlock control status.
  - c. Heating/cooling mode status.
  - d. Optimal run time schedule.
  - e. Start/Stop times.
  - f. Selected mass temperature point ID.
  - g. Optimal run time system normal start times.
  - h. Occupancy and vacancy times.
  - i. Optimal run time system heating/cooling mode parameters.
- 8. Mass temperature summary:
  - a. Mass temperature point type and ID.
  - b. Desired and current mass temperature values.
  - c. Calculated warm-up/cool-down time for each mass temperature.
  - d. Heating/cooling season limits.
  - e. Break point temperature for cooling mode analysis.
- 9. HVAC point summary:
  - a. Control system identifier and status.
  - b. Point ID and status.
  - c. Outside air temperature point ID and status.
  - d. Mass temperature point ID and point.
  - e. Calculated optimal start and stop times.
  - f. Period start.

# 2.13 PROGRAMMING APPLICATION FEATURES

- A. Trend Point:
  - 1. Sample up to 150 points, real or computed, with each point capable of collecting 100 samples at intervals specified in minutes, hours, days, or month.
  - 2. Output trend logs as line graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique pattern, vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.
- B. Alarm Messages:
  - 1. Allow definition of minimum of 100 messages, each having minimum length of 100 characters for each individual message.
  - 2. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totalized point's warning limit, hardware elements advisories.
  - 3. Output assigned alarm with "message requiring acknowledgement".
  - 4. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.
- C. Weekly Scheduling:
  - 1. Automatically initiate equipment or system commands, based on preselected time schedule for points specified.
  - 2. Provide program times for each day of week, per point, with one minute resolution.
  - 3. Automatically generate alarm output for points not responding to command.

- 4. Provide for holidays, minimum of 366 consecutive holidays.
- 5. Operator commands:
  - a. System logs and summaries.
  - b. Start of stop point.
  - c. Lock or unlock control or alarm input.
  - d. Add, delete, or modify analog limits and differentials.
  - e. Adjust point operation position.
  - f. Change point operational mode.
  - g. Open or close point.
  - h. Enable/disable, lock/unlock, or execute interlock sequence or computation profile.
  - i. Begin or end point totalization.
  - j. Modify totalization values and limits.
  - k. Access or secure point.
  - I. Begin or end HVAC or load control system.
  - m. Modify load parameter.
  - n. Modify demand limiting and duty cycle targets.
- 6. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.
- D. Interlocking:
  - 1. Permit events to occur, based on changing condition of one or more associated master points.
  - 2. Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. Same master may monitor or command multiple slaves.
  - 3. Operator commands:
    - a. Define single master/multiple master interlock process.
    - b. Define logic interlock process.
    - c. Lock/unlock program.
    - d. Enable/disable interlock process.
    - e. Execute terminate interlock process.
    - f. Request interlock type summary.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

#### 3.02 INSTALLATION

- A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
- B. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 09 93.
- C. Provide with 120v AC, 15 amp dedicated emergency power circuit to each programmable control unit.
- D. Provide conduit and electrical wiring in accordance with Section 26 27 17. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.
- E. Ensure that all components necessary to execute the sequences of operation are coordinated and installed by all contractors.

F. Contractor shall demolish and remove all existing control components, including but not limited to thermostats, pneumatic tabing, compressors, panels, and devices unless otherwise noted on the drawings. Demolition shall be coordinated on phased projects to maintain the existing system where needed until complete charge-over has been accomplished.

#### 3.03 MANUFACTURER'S FIELD SERVICES

- A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
- B. Provide service engineer to instruct Caesar Rodney School District's representative in operation of systems plant and equipment for 2 day period.
- C. Provide basic operator training for 4 persons on data display, alarm and status descriptors, requesting data, execution of commands and request of logs. Include a minimum of 8 hours dedicated instructor time. Provide training on site.

## 3.04 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate complete and operating system to Caesar Rodney School District.

#### 3.05 MAINTENANCE SERVICE

- A. Provide service and maintenance of energy management and control systems for two years from Date of Substantial Completion.
- B. Provide two complete inspections per year, one in each season, to inspect, calibrate, and adjust controls as required, and submit written reports.
- C. Provide complete service of systems, including call backs. Make minimum of 4 complete normal inspections of approximately 4 hours duration in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports.

# 3.06 SCHEDULES

- A. Input/Output Schedule:
  - 1. Point Description:
  - 2. Digital Input:
    - a. Demand Meter (kW):
    - b. Auxiliary Contact:
    - c. Switches:
      - 1) Switch Closing:
      - 2) Flow Switch:
      - 3) Optical:
    - d. Current:
    - e. Pressure:
  - 3. Digital Output:
    - a. Control Relay:
    - b. Solenoid:
    - c. Contactor:
  - 4. Analog Input:
    - a. Temperature:
    - b. Relative Humidity:
    - c. Pressure/Vacuum:
    - d. Filter:
    - e. Flow:
    - f. Current:
    - g. Liquid Level:
    - h. Photocell:

- 5. Analog Output:
  - a. Pneumatic Transducer:
  - b. 4-20 ma Module:
  - c. 0-16 v DC:
- Alarm: 6.
- B. Input/Output Schedule:
  - 1. Point Description:
  - 2. Inputs:
    - a. Temperature:
    - b. **Relative Humidity:**
    - c. Pressure:
    - d. Flow:
    - e. Level:
    - f. Position:
    - g. Energy: h. Power:
  - 3.
    - Outputs:
      - a. Status:
      - b. Alarm:
      - c. Pneumatic Position:
      - d. Electronic Position:
      - e. Set Point Adjust:
      - f. Start/Stop:
      - g. Off/Low/High:
  - Software Features: 4.
    - a. PID Control (DDC):
    - b. High Limit:
    - c. Low Limit:
    - d. Run Time Totalization:
    - e. Consumption Totalization:
    - Program Start/Stop: f.
    - g. Load Shed:
    - h. Duty Cycle:
    - i. Enthalpy Switchover:
    - Optimal Run Time: j.
    - k. Supply Air Reset:
    - O.A. Interlock: Ι.
    - m. O.A. Temperature Reset:
    - n. Free Cooling Mode:
    - o. Warm-up Mode:
    - p. Boiler Interlock:
    - Chiller Sequencing: q.
    - Energy Calculation: r.
- C. Alarm Schedule:
  - 1. High Limit: A1.
  - 2. Low Limit: A2.
  - 3. Run Time: A3.
  - 4. Maintenance: A4.
  - 5. Status: A5.
  - 6. Override: A6.

- 7. Freeze: A7.
- 8. Low Pressure: A8.

#### **END OF SECTION**

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# SECTION 23 09 93 SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

#### 1.01 PART 1 GENERAL

#### 1.02 SECTION INCLUDES

- A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.
- B. Sequence of operation for:
  - 1. Exhaust Fans
  - 2. Variable Refrigerant Flow (VRF) System
  - 3. Energy Recovery Ventilators with Duct-Mounted Heating Coils
  - 4. Electrical Resistance Radiant and Convective Heating Units
  - 5. Unit Heaters
  - 6. Ductless Split Heat Pumps

#### 1.03 RELATED SECTIONS

- A. Section 23 09 23 Direct-Digital Control System for HVAC.
- B. Section 23 09 13 Instrumentation and Control Devices for HVAC.
- C. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

#### 1.04 SYSTEM DESCRIPTION

- A. This Section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.
- B. Contractor shall provide all controls and interconnecting wiring for the variable refrigerant flow (VRF) system as required in the specifications as well as head-end equipment, controllers, wiring, labor, and software required to integrate the VRF system into the BAS.
- C. Provide controls for the energy recovery ventilators to complete the sequences of operation as outlined below.

#### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
  - 1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
  - 2. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in the contract documents.
  - 3. Include at least the following sequences:
    - a. Start-up.
    - b. Warm-up mode.
    - c. Normal operating mode.
    - d. Unoccupied mode.
    - e. Shutdown.
    - f. Capacity control sequences and equipment staging.
    - g. Temperature and pressure control, such as setbacks, setups, resets, etc.

- h. Detailed sequences for all control strategies, such as economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
- i. Effects of power or equipment failure with all standby component functions.
- j. Sequences for all alarms and emergency shut downs.
- k. Seasonal operational differences and recommendations.
- I. Interactions and interlocks with other systems.
- 4. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
- 5. For packaged controlled equipment, include manufacturer's furnished sequence of operation amplified as required to describe the relationship between the packaged controls and the control system, indicating which points are adjustable control points and which points are only monitored.
- 6. Include schedules, if known.
- C. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
  - 1. Label with settings, adjustable range of control and limits.
  - 2. Include flow diagrams for each control system, graphically depicting control logic.
  - 3. Include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
  - 4. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
  - 5. Include all monitoring, control and virtual points specified in elsewhere.
  - 6. Include a key to all abbreviations.
- D. Points List: Submit list of all control points indicating at least the following for each point.
  - 1. Name of controlled system.
  - 2. Point abbreviation.
  - 3. Point description; such as dry bulb temperature, airflow, etc.
  - 4. Display unit.
  - 5. Control point or setpoint (Yes / No); i.e. a point that controls equipment and can have its setpoint changed.
  - 6. Monitoring point (Yes / No); i.e. a point that does not control or contribute to the control of equipment but is used for operation, maintenance, or performance verification.
  - 7. Intermediate point (Yes / No); i.e. a point whose value is used to make a calculation which then controls equipment, such as space temperatures that are averaged to a virtual point to control reset.
  - 8. Calculated point (Yes / No); i.e. a "virtual" point generated from calculations of other point values.
- E. Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings.

## 1.06 QUALITY ASSURANCE

A. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in Delaware.

## PART 2 PRODUCTS - NOT USED

## PART 3 EXECUTION

## 3.01 GENERAL SYSTEM DESIGN AND OPERATION STANDARDS

- A. Each unit shall be controlled by an individual DDC Controller and all required sensors and appurtenances required to complete the sequence of operation. Units shall include occupied/unoccupied control, night-setback, optimized start/stop, and morning warm-up/cool-down.
- B. The graphic screen associated with each piece of equipment shall have an accessible tab and/or window that includes the full sequence of operation, in written form, specific to the equipment type. This must be clearly visibile within the interface window for the user's reference.
- C. The VRF heat pump units shall be controlled by the BAS. The units shall be controlled by a new DDC controller and DDC-based temperature sensors with no local control adjustment. This shall interface with the factory controller to provide full adjustment as indicated in the sequence below but shall not take the place of the factory controls and safeties governing the refrigeration systems.
- D. The variable-refrigerant-volume heat pump system will interface with the BAS via the factory central controller and room sensors.

## 3.02 EXHAUST FANS

- A. Exhaust Fans Serving Constant Exhaust Storage Rooms
  - 1. Exhaust fans serving chemical storage rooms and janitorial areas shall operate continuously.
  - 2. Exhaust fans serving general storage spaces shall operate on an adjustable occupancy schedule.
  - 3. Ehaust Fan Monitoring:
    - a. Provide a current sensor for each fan to show operational status on monitoring screen at the BAS terminal.
- B. Exhaust Fans Serving Electrical or Mechanical Equipment Rooms
  - 1. Exhaust fans serving electrical rooms or mechanical equipment rooms shall be controlled by a line-voltage thermostat set to engage the fan when the temperature exceeds 85 degrees in the space (adjustable).
  - 2. Provide a motor operated damper on the fan and associated supply-air louver. Dampers to open when fan is enganged.
  - 3. Electrical or Mechanical Equipment Room Exhaust Fan Monitoring
    - a. Provide a current sensor indicating operational status of the fan on the monitoring screen at the BAS terminal.
    - b. Provide a status indicator for each MOD position on the monitoring screen at the BAS terminal via end switch.
    - c. Provide temperature reading in each room on the monitoring screen at the BAS terminal.
    - d. Provide an alarm on the monitoring screen if the temperature exceeds 100 degrees (user adjustable).
- C. Provide a current sensor for each fan to show operational status.
- D. The following items shall be displayed at the Operator's Terminal:
  - 1. Commanded status of fan.
    - 2. Operational status of fan via current sensor.
    - 3. Position of associated motor operated dampers via end-switch.

## 3.03 VARIABLE REFRIGERANT VOLUME HEAT RECOVERY SYSTEMS

- A. The variable refrigerant split system shall have a BAS DDC interface wired to the manufacturer factory central system controller to provide operation, configuration, and monitoring of the system. The manufacturer factory central controller shall operate in BACnet protocol, and be connected to the space temperature sensors as specified.
- B. Sequence of operation:
  - 1. Cooling Mode: Cooling mode shall be selected based on outdoor air temperatures or manually enabled or scheduled from the workstation. During the programmed occupied mode, the supply fan shall run continuously with the outside air dampers open to the minimum position. On a rise in space temperature above the setpoint (75 degrees, adjustable), the manufacturer central controller shall energize the central compressor to provide cooling. The internal capacity control valve in the evaporator unit shall modulate to control the flow of refrigerant to maintain space temperature. On a fall in space temperature the refrigerant capacity control valve shall modulate closed. During the programmed unoccupied mode, the outside air dampers shall remain closed and supply fan and compressor shall engage as needed to maintain unoccupied setpoint (85 deg, adj.).
  - 2. Heating Mode: Heating mode shall be selected based on outdoor air temperatures or manually enabled or scheduled from the workstation. During the programmed occupied mode, the supply fan shall run continuously with the outside air dampers open to the minimum position. On a drop in space temperature below the setpoint (70 degrees, adjustable), the manufacturer central controller shall energize the central compressor with the requisite reversing valve to provide heating to the evaporator unit as required. The internal capacity control valve in the evaporator unit shall modulate to control the flow of refrigerant to maintain space temperature. On a rise in space temperature the refrigerant capacity control valve shall modulate closed. During the programmed unoccupied mode, the outside air dampers shall remain closed and supply fan and compressor shall engage as needed to maintain unoccupied setpoint (55 deg. F, adj.).
  - 3. The following items shall be accessible and displayed at the Operator's Terminal:
    - a. Space temperature setpoint at each fan-coil unit (user adjustable).
    - b. Actual space temperature of each fan-coil unit.
    - c. Operational status of each fan-coil unit (heating, cooling, off, user adjustable).
    - d. Factory error codes from each unit.
    - e. Remote space temperature sensor override for each fan-coil unit (user adjustable to limit temperature adjustment range, heat/cool selection, fan speed).
    - f. All data closets, MDFs, or IDFs shall be provided with warning notification at operator's terminal when temperature exceeds 90 deg. F (adj.).
    - g. Compressor status.
    - h. Accumulated power consumption.
- C. The space shall also be provided with a BAS supplied space temperature sensor that shall trigger an alarm if the space temperature in the MDF or IDF room rises above a designated setpoint (85 degrees, adjustable).

## 3.04 ENERGY RECOVERY VENTILATORS WITH DUCT-MOUNTED HEATING COILS

- A. Energy Recovery Ventilators (ERVs) shall be scheduled for occupied and unoccupied cycles based on an operator adjustable time schedule. Units may also be manually enabled and disabled at the operator workstation. Fan status shall be monitored by the BAS via the fans current sensing relay.
- B. The variable frequency drives shall be set by the balancer to deliver the minimum outdoor air to each associated terminal unit under fully-occupied conditions.

- C. When any heat pump in the area served be the heat recovery unit is in the occupied mode the unit shall be energized.
  - 1. The unit exhaust and outside air motorized isolation dampers shall open.
  - 2. Provide proof of airflow for each fan and provide fan failure alarms.
  - 3. Provide temperature sensors at outside air inlet, supply air outlet, return air inlet, and exhaut air outlet.
  - 4. For all units, duct smoke detectors shall be provided by the electrical contractor at supply and return airstreams. Provide the interlock wiring to shut down the units upon activation.
  - 5. The electric heating coil shall be energized and modulate via SCR control to maintain a discharge air (supply air) temperature of 60 degrees.
- D. The following items shall be displayed at the operators workstation:
  - 1. Supply air temperature downstream of ERV.
  - 2. Supply air temperature downstream of duct heating coil.
  - 3. Return air temperature.
  - 4. Exhaust air temperature.
  - 5. Outside air temperature, humidity and enthalpy.
  - 6. Fan operational status via current sensor, supply and exhaust fans.
  - 7. Commanded status of each fan.
  - 8. Commanded status of heating coils (as applicable).
  - 9. Commanded position of dampers.
  - 10. Diagram showing the layout of the unit with major components and dynamic temperatures shown where temperature sensors exist in the system.

#### 3.05 DUCTLESS SPLIT HEAT PUMPS

- A. The split system shall have a BAS DDC interface wired to the manufacturer factory central system controller to provide operation, configuration, and monitoring of the system. The manufacturer factory controller shall operate in BACnet protocol, and be connected to the space temperature sensors as specified.
- B. Sequence of operation:
  - 1. Cooling Mode: The supply fan and compressor shall engage as needed to maintain setpoint (75 deg, adj.).
  - 2. Heating Mode: The supply fan, compressor, and reversing valve shall engage as needed to maintain setpoint (70 deg. F, adj.).
  - 3. The following items shall be accessible and displayed at the Operator's Terminal:
    - a. Space temperature setpoint at each fan-coil unit (user adjustable).
      - b. Actual space temperature of each fan-coil unit.
      - c. Operational status of each fan-coil unit (heating, cooling, off, user adjustable).
    - d. Factory error codes from each unit.
    - e. Remote space temperature sensor override for each fan-coil unit (user adjustable to limit temperature adjustment range, heat/cool selection, fan speed).
    - f. Compressor status.
    - g. Accumulated power consumption.
- C. The space shall also be provided with a BAS supplied space temperature sensor that shall trigger an alarm if the space temperature in the MDF or IDF room rises above a designated setpoint (85 degrees, adjustable).

## 3.06 ELECTRIC RESISTANCE RADIANT AND CONVECTIVE HEATING UNITS

A. The electric-resistance radiant and convective heating units shall be controlled by an individual DDC controller and space temperature sensor. Single temperature room temperature sensor maintains constant space temperature of 70 degrees F (adj.) by cycling heating element.

- 1. Provide a current sensor indicating operational status of the heating unit on the monitoring screen at the BAS terminal.
- B. The following items shall be displayed at the Operator's Terminal:
  - 1. Temperature Setpoint.
  - 2. Actual Space Temperature.
  - 3. Alarms.

## 3.07 CABINET HEATERS

- A. The electric cabinet heaters shall be controlled by an individual DDC controller and space temperature sensor. Single temperature room temperature sensor maintains constant space temperature of 70 degrees F (adj.) by cycling fan and heating element.
  - 1. Provide a current sensor indicating operational status of the heating unit on the monitoring screen at the BAS terminal.
- B. The following items shall be displayed at the Operator's Terminal:
  - 1. Temperature Setpoint.
  - 2. Actual Space Temperature.
  - 3. Alarms.

#### 3.08 UNIT HEATERS

- A. Each unit shall be controlled by an individual DDC controller and space temperature sensor. Single temperature room temperature sensor maintains constant space temperature of 70 degrees F (adj.) by cycling unit fan motor and heating element or gas valve.
- B. The following items shall be displayed at the Operator's Terminal:
  - 1. Temperature Setpoint.
  - 2. Actual Space Temperature.
  - 3. Alarms.
- C. The factory gas train shall control all integral combustion components and safeties for the system.

#### END OF SECTION

# SECTION 23 21 13 HYDRONIC PIPING

#### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Pipe and pipe fittings for:
  - 1. Equipment drains and overflows, including condensate drain piping.
- B. Pipe hangers and supports.
- C. Valves:
  - 1. Ball valves.
  - 2. Check valves.
  - 3. Backwater valves.

# 1.02 RELATED REQUIREMENTS

- A. Section 08 31 00 Access Doors and Panels.
- B. Section 09 90 00 Painting and Coating.
- C. Section 22 05 48 Vibration and Seismic Controls for Plumbing Piping and Equipment.
- D. Section 22 05 53 Identification for Plumbing Piping and Equipment.
- E. Section 22 07 19 Plumbing Piping Insulation.
- F. Section 22 05 16 Expansion Fittings and Loops for Plumbing Piping.
- G. Section 23 05 16 Expansion Fittings and Loops for HVAC Piping.
- H. Section 23 05 48 Vibration and Seismic Con. for Equipment.
- I. Section 23 05 53 Identification for HVAC Piping and Equipment.
- J. Section 23 07 19 HVAC Piping Insulation.
- K. Section 23 21 14 Hydronic Specialties.

## 1.03 REFERENCE STANDARDS

- A. ASME BPVC-IX Boiler and Pressure Vessel Code, Section IX Welding, Brazing, and Fusing Qualifications.
- B. ASME B16.3 Malleable Iron Threaded Fittings; The American Society of Mechanical Engineers.
- C. ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings.
- D. ASME B16.22 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- E. ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers.
- F. ASME B31.5 Refrigeration Piping and Heat Transfer Components; The American Society of Mechanical Engineers.
- G. ASME B31.9 Building Services Piping; The American Society of Mechanical Engineers (ANSI/ASME B31.9).
- H. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- I. ASTM A234/A234M Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- J. ASTM B32 Standard Specification for Solder Metal.
- K. ASTM B88 Standard Specification for Seamless Copper Water Tube.

- L. ASTM B88M Standard Specification for Seamless Copper Water Tube (Metric).
- M. ASTM D1785 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- N. ASTM D2235 Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
- O. ASTM D2241 Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
- P. ASTM D2310 Standard Classification for Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
- Q. ASTM D2466 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- R. ASTM D2467 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- S. ASTM D2680 Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.
- T. ASTM D2751 Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
- U. ASTM D2855 Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
- V. ASTM F708 Standard Practice for Design and Installation of Rigid Pipe Hangers.
- W. ASTM F876 Standard Specification for Crosslinked Polyethylene (PEX) Tubing.
- X. ASTM F1476 Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
- Y. ASTM F877 Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
- Z. AWS A5.8/A5.8M Specification for Filler Metals for Brazing and Braze Welding; American Welding Society.
- AA. AWS D1.1/D1.1M Structural Welding Code Steel.
- AB. AWWA C105/A21.5 Polyethylene Encasement for Ductile-Iron Pipe Systems; American Water Works Association (ANSI/AWWA C105/A21.5).
- AC. AWWA C110/A21.10 Ductile-Iron and Gray-Iron Fittings.
- AD. AWWA C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- AE. AWWA C151/A21.51 Ductile-Iron Pipe, Centrifugally Cast.
- AF. AWWA C606 Grooved and Shouldered Joints.
- AG. AWWA C606 Standard Specification for Grooved and Shouldered Joints; American Water Works Association.
- AH. MSS SP-58 Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation.

## 1.04 SYSTEM DESCRIPTION

- A. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- B. Use non-conducting dielectric connections whenever jointing dissimilar metals.
- C. Provide pipe hangers and supports in accordance with ASME B31.9 unless indicated otherwise.

D. Use 3/4 inch gate or ball valves with cap for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

#### 1.05 SUBMITTALS

- A. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- B. Welders Certificate: Include welders certification of compliance with ASME (BPV IX).
- C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- D. Project Record Documents: Record actual locations of valves.
- E. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

#### **1.06 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified in this section, with minimum three years of experience.
- C. Welder Qualifications: Certify in accordance with ASME (BPV IX).

## 1.07 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 code for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.
- C. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

## 1.08 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

## 1.09 FIELD CONDITIONS

A. Do not install underground piping when bedding is wet or frozen.

## 1.10 EXTRA MATERIALS

A. Provide two repacking kits for each size and valve type.

## PART 2 PRODUCTS

## 2.01 EQUIPMENT DRAINS AND OVERFLOWS

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn; using one of the following joint types:
  - 1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
  - 2. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
  - 3. Joints: Solder, lead free, ASTM B 32, HB alloy (95-5 tin-antimony), or tin and silver.
- B. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.

- 1. Fittings: ASTM D2466 or D2467, PVC.
- 2. Joints: Solvent welded in accordance with ASTM D2855.

#### 2.02 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
  - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
- B. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
- C. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- D. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
- E. Vertical Support: Steel riser clamp.
- F. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- G. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
- H. Inserts: Malleable iron case of steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

## 2.03 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

- A. Unions for Pipe 2 Inches and Under:
  - 1. Ferrous Piping: 150 psig malleable iron, threaded.
  - 2. Copper Pipe: Bronze, soldered joints.
- B. Flanges for Pipe Over 2 Inches:
  - 1. Ferrous Piping: 150 psig forged steel, slip-on.
  - 2. Copper Piping: Bronze.
  - 3. Gaskets: 1/16 inch thick preformed neoprene.
- C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
  - 1. Dimensions and Testing: In accordance with AWWA C606.
  - 2. Mechanical Couplings: Comply with ASTM F1476.
  - 3. Housing Material: Malleable iron or ductile iron, galvanized.
  - 4. Housing Clamps: Malleable iron galvanized to engage and lock, designed to permit some angular deflection, contraction, and expansion.
  - 5. Gasket Material: EPDM suitable for operating temperature range from -30 degrees F to 230 degrees F.
  - 6. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
  - 7. When pipe is field grooved, provide coupling manufacturer's grooving tools.
- D. Dielectric Connections: Union or waterway fitting with water impervious isolation barrier and one galvanized or plated steel end and one copper tube end, end types to match pipe joint types used.

# 2.04 BALL VALVES

- A. Manufacturers:
  - 1. Conbraco Industries: www.conbraco.com.
  - 2. Grinnell Products, a Tyco Business: www.grinnell.com.
  - 3. Nibco, Inc: www.nibco.com.
  - 4. Milwaukee Valve Company: www.milwaukeevalve.com.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.

- B. Up To and Including 2 Inches:
  - 1. Bronze one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.
- C. Over 2 Inches:
  - 1. Ductile iron body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, grooved ends or flanged, rated to 800 psi.
  - 2. Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, flanged.

#### 2.05 BACKWATER VALVES

- A. Cast iron body with backwater ball float backwater valve.
- B. Provide with 100% positive seal.

#### 2.06 SWING CHECK VALVES

- A. Manufacturers:
  - 1. Hammond Valve: www.hammondvalve.com.
  - 2. Nibco, Inc: www.nibco.com.
  - 3. Victaulic Company; Model \_\_\_\_: www.victaulic.com.
  - 4. Milwaukee Valve Company: www.milwaukeevalve.com.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
- B. Up To and Including 2 Inches:
  - 1. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder ends.
- C. Over 2 Inches:
  - 1. Iron body, bronze trim, stainless steel, bronze, or bronze faced rotating swing disc, renewable disc and seat, flanged or grooved ends.
  - 2. Iron body, bronze trim, bronze or bronze faced rotating swing disc, renewable disc and seat, flanged ends.

#### 2.07 SPRING LOADED CHECK VALVES

- A. Manufacturers:
  - 1. Hammond Valve: www.hammondvalve.com.
  - 2. Crane Co.: www.cranevalve.com.
  - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
  - 4. Victaulic Company; Model \_\_\_\_: www.victaulic.com.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
- B. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer or threaded lug ends.

#### PART 3 EXECUTION

#### 3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.
- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare piping connections to equipment using jointing system specified.
- E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- F. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for additional requirements.

#### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. All condensate drain piping concealed above inaccessible ceilings, behind walls, or exterior to buildng shall be provided as copper.
- C. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- D. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- E. Install piping to conserve building space and to avoid interfere with use of space.
- F. Group piping whenever practical at common elevations.
- G. Sleeve pipe passing through partitions, walls and floors.
- H. Slope piping and arrange to drain at low points.
- I. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16.
- J. Inserts:
  - 1. Provide inserts for placement in concrete formwork.
  - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
  - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
  - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
  - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.
- K. Pipe Hangers and Supports:
  - 1. Install in accordance with ASME B31.9.
  - 2. Support horizontal piping as scheduled.
  - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
  - 4. Place hangers within 12 inches of each horizontal elbow.
  - 5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
  - 6. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
  - 7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
  - 8. Provide copper plated hangers and supports for copper piping.
  - 9. Prime coat exposed steel hangers and supports. Refer to Section 09 90 00. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- L. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 07 19.
- M. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 23 07 19.
- N. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 31 00.
- O. Use eccentric reducers to maintain top of pipe level.
- P. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

- Q. Install valves with stems upright or horizontal, not inverted.
- R. Install backwater valves plumb and level, test operation.

#### 3.03 SCHEDULES

- A. Hanger Spacing for Copper Tubing.
  - 1. 1/2 inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
  - 2. 1 inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
  - 3. 1-1/2 inch and 2 inch: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 4. 2-1/2 inch: Maximum span, 9 feet; minimum rod size, 3/8 inch.
  - 5. 3 inch: Maximum span, 10 feet; minimum rod size, 3/8 inch.
  - 6. 4 inch: Maximum span, 12 feet; minimum rod size, 1/2 inch.
  - 7. 6 inch: Maximum span, 14 feet; minimum rod size, 1/2 inch.
  - 8. 8 inch: Maximum span, 16 feet; minimum rod size, 5/8 inch.
  - 9. 10 inch: Maximum span, 18 feet; minimum rod size, 3/4 inch.
  - 10. 12 inch: Maximum span, 19 feet; minimum rod size, 7/8 inch.
- B. Hanger Spacing for Steel Piping.
  - 1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
  - 2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
  - 4. 2 inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
  - 5. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
  - 6. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
  - 7. 4 inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.
  - 8. 6 inches: Maximum span, 17 feet; minimum rod size, 1/2 inch.
  - 9. 8 inches: Maximum span, 19 feet; minimum rod size, 5/8 inch.
  - 10. 10 inches: Maximum span, 20 feet; minimum rod size, 3/4 inch.
  - 11. 12 inches: Maximum span, 23 feet; minimum rod size, 7/8 inch.
  - 12. 14 inches: Maximum span, 25 feet; minimum rod size, 1 inch.
  - 13. 16 inches: Maximum span, 27 feet; minimum rod size, 1 inch.
  - 14. 18 inches: Maximum span, 28 feet; minimum rod size, 1-1/4 inch.
  - 15. 20 inches: Maximum span, 30 feet; minimum rod size, 1-1/4 inch.
- C. Hanger Spacing for Plastic Piping.
  - 1. 1/2 inch: Maximum span, 42 inches; minimum rod size, 1/4 inch.
  - 2. 3/4 inch: Maximum span, 45 inches; minimum rod size, 1/4 inch.
  - 3. 1 inch: Maximum span, 51 inches; minimum rod size, 1/4 inch.
  - 4. 1-1/4 inches: Maximum span, 57 inches; minimum rod size, 3/8 inch.
  - 5. 1-1/2 inches: Maximum span, 63 inches; minimum rod size, 3/8 inch.
  - 6. 2 inches: Maximum span, 69 inches; minimum rod size, 3/8 inch.
  - 7. 3 inches: Maximum span, 7 feet; minimum rod size, 3/8 inch.
  - 8. 4 inches: Maximum span, 8 feet; minimum rod size, 1/2 inch.
  - 9. 6 inches: Maximum span, 10 feet; minimum rod size, 1/2 inch.
  - 10. 8 inches: Maximum span, 11 feet; minimum rod size, 5/8 inch.
  - 11. 10 inches: Maximum span, 13 feet; minimum rod size, 3/4 inch.
  - 12. 12 inches: Maximum span, 14 feet; minimum rod size, 7/8 inch.
  - 13. 14 inches: Maximum span, 15 feet; minimum rod size, 1 inch.
  - 14. 16 inches: Maximum span, 16 feet; minimum rod size, 1 inch.
  - 15. 18 inches: Maximum span, 18 feet; minimum rod size, 1-1/4 inch.

#### **END OF SECTION**

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# SECTION 23 23 00 REFRIGERANT PIPING

#### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.
- E. Strainers.
- F. Check valves.
- G. Pressure relief valves.
- H. Filter-driers.
- I. Solenoid valves.
- J. Expansion valves.
- K. Receivers.
- L. Flexible connections.

## 1.02 RELATED REQUIREMENTS

- A. Section 08 31 00 Access Doors and Panels.
- B. Section 09 90 00 Painting and Coating.
- C. Section 22 07 19 Plumbing Piping Insulation.
- D. Section 22 07 16 Plumbing Equipment Insulation.
- E. Section 23 54 00 Furnaces.
- F. Section 23 61 00 Refrigerant Compressors.
- G. Section 23 62 13 Packaged Air-Cooled Refrigerant Compressor and Condenser Units.
- H. Section 23 63 13 Air Cooled Refrigerant Condensers.
- I. Section 23 81 24 Computer Room Air Conditioners Floor Mounted.
- J. Section Air Coils.
- K. Section 23 09 93 Sequence of Operations for HVAC Controls.
- L. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

## 1.03 REFERENCE STANDARDS

- A. AHRI 495 Performance Rating of Refrigerant Liquid Receivers.
- B. AHRI 710 Performance Rating of Liquid-Line Driers.
- C. AHRI 730 Flow Capacity Rating and Application of Suction-Line Filters and Suction-Line Filter-Driers.
- D. AHRI 750 Standard for Thermostatic Refrigerant Expansion Valves.
- E. AHRI 760 Standard for Performance Rating of Solenoid Valves for Use With Volatile Refrigerants.
- F. ASHRAE Std 15 Safety Standard for Refrigeration Systems.
- G. ASHRAE Std 34 Designation and Safety Classification of Refrigerants.

- H. ASME BPVC-VIII-1 Boiler and Pressure Vessel Code, Section VIII, Division 1 Rules for Construction of Pressure Vessels.
- I. ASME BPVC-IX Boiler and Pressure Vessel Code, Section IX Welding, Brazing, and Fusing Qualifications.
- J. ASME B16.22 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- K. ASME B16.26 Cast Copper Alloy Fittings for Flared Copper Tubes.
- L. ASME B31.5 Refrigeration Piping and Heat Transfer Components.
- M. ASME B31.9 Building Services Piping.
- N. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- O. ASTM A234/A234M Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- P. ASTM B88 Standard Specification for Seamless Copper Water Tube.
- Q. ASTM B88M Standard Specification for Seamless Copper Water Tube (Metric).
- R. ASTM B280 Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- S. ASTM F708 Standard Practice for Design and Installation of Rigid Pipe Hangers.
- T. AWS A5.8M/A5.8 Specification for Filler Metals for Brazing and Braze Welding.
- U. AWS D1.1/D1.1M Structural Welding Code Steel.
- V. MSS SP-58 Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation.
- W. MSS SP-69 Pipe Hangers and Supports Selection and Application; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc..
- X. MSS SP-89 Pipe Hangers and Supports Fabrication and Installation Practices; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc..
- Y. UL 429 Electrically Operated Valves.

## **1.04 SYSTEM DESCRIPTION**

- A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- B. Provide pipe hangers and supports in accordance with MSS SP-69 unless indicated otherwise.
- C. Liquid Indicators:
  - 1. Use line size liquid indicators in main liquid line leaving condenser.
  - 2. If receiver is provided, install in liquid line leaving receiver.
  - 3. Use line size on leaving side of liquid solenoid valves.
- D. Valves:
  - 1. Use service valves on suction and discharge of compressors.
  - 2. Use gage taps at compressor inlet and outlet.
  - 3. Use gage taps at hot gas bypass regulators, inlet and outlet.
  - 4. Use check valves on compressor discharge.
  - 5. Use check valves on condenser liquid lines on multiple condenser systems.
- E. Refrigerant Charging (Packed Angle) Valve: Use in liquid line between receiver shut-off valve and expansion valve.

- F. Strainers:
  - 1. Use line size strainer upstream of each automatic valve.
  - 2. Where multiple expansion valves with integral strainers are used, use single main liquid line strainer.
  - 3. On steel piping systems, use strainer in suction line.
  - 4. Use shut-off valve on each side of strainer.
- G. Pressure Relief Valves: Use on ASME receivers and pipe to outdoors.
- H. Filter-Driers:
  - 1. Use a filter-drier immediately ahead of liquid-line controls, such as thermostatic expansion valves, solenoid valves, and moisture indicators.
  - 2. Use a filter-drier on suction line just ahead of compressor.
  - 3. Use sealed filter-driers in lines smaller than 1/2 inch outside diameter.
  - 4. Use sealed filter-driers in low temperature systems.
  - 5. Use sealed filter-driers in systems utilizing hermetic compressors.
  - 6. Use replaceable core filter-driers in lines of 1/2 inch outside diameter or greater.
  - 7. Use replaceable core liquid-line filter-driers in systems utilizing receivers.
  - 8. Use filter-driers for each solenoid valve.
- I. Solenoid Valves:
  - 1. Use in liquid line of systems operating with single pump-out or pump-down compressor control.
  - 2. Use in liquid line of single or multiple evaporator systems.
  - 3. Use in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.
- J. Receivers:
  - 1. Use on systems five tons and larger, sized to accommodate pump down charge.
  - 2. Use on systems with long piping runs.
- K. Flexible Connectors: Utilize at or near compressors where piping configuration does not absorb vibration.

#### 1.05 SUBMITTALS

- A. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- B. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.
- C. Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- D. Test Reports: Indicate results of leak test, acid test.
- E. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.
- F. Submit welders certification of compliance with ASME (BPV IX) or AWS D1.1.
- G. Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.
- H. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.

#### 1.06 QUALITY ASSURANCE

A. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum five years of documented experience.

- B. Design piping system under direct supervision of a Professional Engineer experienced in design of this type of work.
- C. Design piping system under direct supervision of a Professional Engineer experienced in design of this type of work and licensed in Delaware.

#### 1.07 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.
- C. Welders Certification: In accordance with ASME (BPV IX) or AWS D1.1.
- D. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

#### 1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties in shipping containers with labeling in place.
- B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

#### 1.09 MAINTENANCE PRODUCTS

- A. See Section 01 6000 Product Requirements, for additional provisions.
- B. Provide two refrigeration oil test kits each containing everything required to conduct one test.
- C. Provide two filter-dryer cartridges of each type.

## PART 2 PRODUCTS

## 2.01 PIPING

- A. Copper Tube: ASTM B280, H58 hard drawn .
  - 1. Fittings: ASME B16.22 wrought copper.
  - 2. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy.
- B. Copper Tube to 7/8 inch OD: ASTM B88 (ASTM B88M), Type K (A), annealed.
  - 1. Fittings: ASME B16.26 cast copper.
  - 2. Joints: Flared.
- C. Pipe Supports and Anchors:
  - 1. Conform to ASTM F 708, MSS SP-58, MSS SP-69, and MSS SP-89.
  - 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Carbon steel adjustable swivel, split ring.
  - 3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
  - 4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
  - 5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
  - 6. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
  - 7. Vertical Support: Steel riser clamp.
  - 8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
  - 9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
  - 10. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
  - 11. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

#### 2.02 MOISTURE AND LIQUID INDICATORS

- A. Manufacturers:
  - 1. Henry Technologies: www.henrytech.com.
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: www.parker.com.
  - 3. Sporlan Valve Company: www.sporlan.com.
- B. Indicators: Single or Doubleport type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

#### 2.03 VALVES

- A. Manufacturers:
  - 1. Hansen Technologies Corporation: www.hantech.com.
  - 2. Henry Technologies: www.henrytech.com.
  - 3. Danfoss Flomatic: www.flomatic.com.
- B. Diaphragm Packless Valves:
  - 1. UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, solder or flared ends, with positive backseating; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.
- C. Packed Angle Valves:
  - 1. Forged brass or nickel plated forged steel, forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, solder or flared ends; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.
- D. Ball Valves:
  - 1. Two piece bolted forged brass body with teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psi and maximum temperature of 300 degrees F.
- E. Service Valves:
  - 1. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or solder ends, for maximum pressure of 500 psi.

#### 2.04 STRAINERS

- A. Straight Line or Angle Line Type:
  - 1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.
- B. Straight Line, Non-Cleanable Type:
  - 1. Steel shell, copper plated fittings, stainless steel wire screen, for maximum working pressure of 500 psi.

#### 2.05 CHECK VALVES

- A. Manufacturers:
  - 1. Hansen Technologies Corporation: www.hantech.com.
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: www.parker.com.
  - 3. Sporlan Valve Company: www.sporlan.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Globe Type:

- 1. Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, teflon seat disc; for maximum temperature of 300 degrees F and maximum working pressure of 500 psi.
- C. Straight Through Type:
  - 1. Brass body and disc, phosphor-bronze or stainless steel spring, neoprene seat; for maximum working pressure of 500 psi and maximum temperature of 200 degrees F.

#### 2.06 PRESSURE REGULATORS

- A. Manufacturers:
  - 1. Hansen Technologies Corporation: www.hantech.com.
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: www.parker.com.
  - 3. Sporlan Valve Company: www.sporlan.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Brass body, stainless steel diaphragm, direct acting, adjustable over 0 to 80 psi range, for maximum working pressure of 450 psi.

#### 2.07 PRESSURE RELIEF VALVES

- A. Manufacturers:
  - 1. Hansen Technologies Corporation: www.hantech.com.
  - 2. Henry Technologies: www.henrytech.com.
  - 3. Sherwood Valve/Harsco Corporation: www.sherwoodvalve.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB, selected to ASHRAE Std 15, with standard setting of 425 psi, adjusted to meet system requirements.

## 2.08 FILTER-DRIERS

- A. Manufacturers:
  - 1. Flow Controls Division of Emerson Electric: www.emersonflowcontrols.com.
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: www.parker.com.
  - 3. Sporlan Valve Company: www.sporlan.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Performance:
  - 1. Flow Capacity Liquid Line: As indicated in schedule, minimum, rated in accordance with AHRI 710.
  - 2. Flow Capacity Suction Line: As indicated in schedule, minimum, rated in accordance with AHRI 730.
  - 3. Water Capacity: As indicated in schedule, rated in accordance with AHRI 710.
  - 4. Pressure Drop: 2 psi, As indicated in schedule, maximum, when operating at full connected evaporator capacity.
  - 5. Design Working Pressure: As indicated in schedule or 350 psi, minimum.
- C. Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, activated charcoal, and filtration to 40 microns; of construction that will not pass into refrigerant lines.
- D. Construction: UL listed.
  - 1. Replaceable Core Type: Steel shell with removable cap.
  - 2. Sealed Type: Copper shell.
  - 3. Connections: As specified for applicable pipe type.

# 2.09 SOLENOID VALVES

A. Manufacturers:

- 1. Flow Controls Division of Emerson Electric: www.emersonflowcontrols.com.
- 2. Parker Hannifin/Refrigeration and Air Conditioning: www.parker.com.
- 3. Sporlan Valve Company: www.sporlan.com.
- B. Valve: AHRI 760, pilot operated, copper or brass body and internal parts, synthetic seat, stainless steel stem and plunger assembly (permitting manual operation in case of coil failure), integral strainer, with flared, solder, or threaded ends; for maximum working pressure of 500 psi.
- C. Coil Assembly: UL 429, UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color coded lead wires, integral junction box with pilot light.
- D. Electrical Characteristics: per drawings.

## 2.10 EXPANSION VALVES

- A. Manufacturers:
  - 1. Flow Controls Division of Emerson Electric: www.emersonflowcontrols.com.
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: www.parker.com.
  - 3. Sporlan Valve Company: www.sporlan.com.
- B. Angle or Straight Through Type: AHRI 750; design suitable for refrigerant, brass body, internal or external equalizer, mechanical pressure limit (maximum operating pressure MOP feature), adjustable superheat setting, replaceable inlet strainer, with replaceable capillary tube and remote sensing bulb and remote bulb well.
- C. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F superheat. Select to avoid being undersized at full load and excessively oversized at part load.

## 2.11 ELECTRONIC EXPANSION VALVES

- A. Manufacturers:
  - 1. Danfoss Automatic Controls: www.danfoss.com.
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: www.parker.com.
  - 3. Sporlan Valve Company: www.sporlan.com.
- B. Valve:
  - 1. Brass body with flared or solder connection, needle valve with floating needle and machined seat, stepper motor drive.
  - 2. Capacity: per drawings.
  - 3. Electrical Characteristics: per drawings.
- C. Evaporation Control System:
  - 1. Electronic microprocessor based unit in enclosed case, proportional integral control with adaptive superheat, maximum operating pressure function, preselection allowance for electrical defrost and hot gas bypass.
  - 2. Electrical Characteristics: per drawings.
- D. Refrigeration System Control: Electronic microprocessor based unit in enclosed case, with proportional integral control of valve, on/off thermostat, air temperature alarm (high and low), solenoid valve control, liquid injection adaptive superheat control, maximum operating pressure function, night setback thermostat, timer for defrost control.

## 2.12 RECEIVERS

- A. Manufacturers:
  - 1. Henry Technologies: www.henrytech.com.
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: www.parker.com.

- 3. Sherwood Valve/Harsco Corporation: www.sherwoodvalve.com.
- B. Internal Diameter 6 inch and Smaller:
  - 1. AHRI 495, UL listed, steel, brazed; 400 psi maximum pressure rating, with tappings for inlet, outlet, and pressure relief valve.
- C. Internal Diameter Over 6 inch:
  - 1. AHRI 495, welded steel, tested and stamped in accordance with ASME (BPV VIII, 1); 400 psi with tappings for liquid inlet and outlet valves, pressure relief valve, and magnetic liquid level indicator.

#### 2.13 FLEXIBLE CONNECTORS

- A. Manufacturers:
  - 1. Circuit Hydraulics, Ltd: www.circuit-hydraulics.co.uk.
  - 2. Flexicraft Industries: www.flexicraft.com.
  - 3. Penflex: www.penflex.com.
- B. Corrugated stainless steel or bronze hose with single layer of stainless steel exterior braiding, minimum 9 inches long with copper tube ends; for maximum working pressure of 500 psi.

# PART 3 EXECUTION

#### 3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

#### 3.02 INSTALLATION

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Inserts:
  - 1. Provide inserts for placement in concrete formwork.
  - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
  - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
  - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
  - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of or recessed into and grouted flush with slab.
- G. Pipe Hangers and Supports:
  - 1. Install in accordance with ASTM F 708 and MSS SP-89.
  - 2. Support horizontal piping as scheduled.
  - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
  - 4. Place hangers within 12 inches of each horizontal elbow.
- 5. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
- 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- 7. Provide copper plated hangers and supports for copper piping.
- H. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- I. Provide clearance for installation of insulation and access to valves and fittings.
- J. Provide access to concealed valves and fittings. Coordinate size and location of access doors with Section 08 31 00.
- K. Flood piping system with nitrogen when brazing.
- L. Where pipe support members are welded to structural building frame, brush clean, and apply one coat of zinc rich primer to welding.
- M. Prepare unfinished pipe, fittings, supports, and accessories ready for finish painting. Refer to Section 09 90 00.
- N. Insulate piping and equipment; refer to Section and Section 22 07 16.
- O. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
- P. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.
- Q. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
- R. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
- S. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.
- T. Fully charge completed system with refrigerant after testing.
- U. Provide electrical connection to solenoid valves. Refer to Section 26 27 17.

#### 3.03 FIELD QUALITY CONTROL

- A. Test refrigeration system in accordance with ASME B31.5.
- B. Pressure test system with dry nitrogen to 200 psi. Perform final tests at 27 inches vacuum and 200 psi using electronic leak detector. Test to no leakage.

## 3.04 SCHEDULES

- A. Hanger Spacing for Copper Tubing.
  - 1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 3/8 inch.
  - 2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 3/8 inch.
  - 3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
  - 4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 5. 2-1/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 6. 2-5/8 inch OD: Maximum span, 9 feet; minimum rod size, 3/8 inch.
  - 7. 3-1/8 inch OD: Maximum span, 10 feet; minimum rod size, 3/8 inch.
  - 8. 3-5/8 inch OD: Maximum span, 11 feet; minimum rod size, 1/2 inch.
  - 9. 4-1/8 inch OD: Maximum span, 12 feet; minimum rod size, 1/2 inch.
- B. Hanger Spacing for Steel Piping.
  - 1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 3/8 inch.
  - 2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.

- 4. 2 inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- 5. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
- 6. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
- 7. 4 inches: Maximum span, 12 feet; minimum rod size, 1/2 inch.

# END OF SECTION

# SECTION 23 31 00 HVAC DUCTS AND CASINGS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Metal ductwork.
- B. Casing and plenums.

## 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete.
- B. Section 09 90 00 Painting and Coating: Weld priming, weather resistant, paint or coating.
- C. Section 11 40 00 Foodservice Equipment: Supply of kitchen range hoods for placement by this Section.
- D. Section 23 07 13 Duct Insulation: External insulation and duct liner.
- E. Section 23 33 00 Air Duct Accessories.
- F. Section 23 36 00 Air Terminal Units.
- G. Section 23 37 00 Air Outlets and Inlets.
- H. Section 23 05 93 Testing, Adjusting, and Balancing for HVAC.

## 1.03 REFERENCE STANDARDS

- A. ASTM A36/A36M Standard Specification for Carbon Structural Steel.
- B. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- C. ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
- D. ASTM A1008/A1008M Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
- E. ASTM A1011/A1011M Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
- F. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- G. ASTM B209M Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric].
- H. ASTM C14 Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
- I. ASTM C14M Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe (Metric).
- J. ASTM C443 Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
- K. ASTM C443M Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric).
- L. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems.
- M. NFPA 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- N. NFPA 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

- O. SMACNA (LEAK) HVAC Air Duct Leakage Test Manual; Sheet Metal and Air Conditioning Contractors' National Association.
- P. SMACNA (DCS) HVAC Duct Construction Standards Metal and Flexible.
- Q. SMACNA (FGD) Fibrous Glass Duct Construction Standards.
- R. UL 181 Standard for Factory-Made Air Ducts and Air Connectors.
- S. IECC 2012 International Energy Conservation Code Duct construciton standards, leakage testing

## 1.04 PERFORMANCE REQUIREMENTS

A. No variation of duct configuration or sizes permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data for duct materials and duct connections.
- C. Shop Drawings: Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work for all systems.
- D. <u>MANDATORY Test Reports</u>: Pressure test all ductwork. Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA (LEAK) -HVAC Air Duct Leakage Test Manual.
  - 1. Utilize standard equation CL=FP^0.65 where F= Measured leakage rate in CFM per 100 square feet of duct surface, and P = Static Pressure of the test.
- E. Manufacturer's Certificate: Certify that installation of glass fiber ductwork meet or exceed recommended fabrication and installation requirements.
- F. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

## 1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum five years of documented experience.

## 1.07 REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA 90A, NFPA 90B, and NFPA 96 standards.

## 1.08 FIELD CONDITIONS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures within acceptable range during and after installation of duct sealants.

## PART 2 PRODUCTS

## 2.01 DUCT ASSEMBLIES

## 2.02 MATERIALS

- A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.
- B. Aluminum for Ducts: ASTM B209 (ASTM B209M); aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T651 or of equivalent strength.

- C. Stainless Steel for Ducts: ASTM A 240/A 240M, Type 304.
- D. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.
- E. Flexible Ducts:
  - 1. Two ply vinyl film supported by helically wound spring steel wire.
    - a. Pressure Rating: 10 inches WG positive and 1.0 inches WG negative.
    - b. Maximum Velocity: 4000 fpm.
    - c. Temperature Range: -10 degrees F to 160 degrees F.
- F. Insulated Flexible Ducts:
  - 1. Two ply vinyl film supported by helically wound spring steel wire; fiberglass insulation; polyethylene vapor barrier film.
    - a. Pressure Rating: 10 inches WG positive and 1.0 inches WG negative.
    - b. Maximum Velocity: 4000 fpm.
    - c. Temperature Range: -10 degrees F to 160 degrees F.
- G. Stainless Steel Ducts: ASTM A 666, Type 304.
- H. All Ducts: Galvanized steel, unless otherwise indicated.
- I. Low Pressure Supply (Heating Systems): 1 inch w.g. pressure class, galvanized steel.
- J. Low Pressure Supply (System with Cooling Coils): 1 inch w.g. pressure class, galvanized steel.
- K. Medium and High Pressure Supply (All VAV Primary Supply Duct between AHU and VAV Terminal Unit): 2 inch w.g. pressure class, galvanized steel.
- L. Return and Relief: 1 inch w.g. pressure class, galvanized steel.
- M. General Exhaust: 1 inch w.g. pressure class, galvanized steel.
- N. Kitchen Cooking Hood Exhaust: 1/2 inch w.g. pressure class, galvanized steel.
  - 1. Asphalt base.
  - 2. Construct of 18 gage stainless steel using continuous external welded joints in rectangular sections.
- O. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
  - 1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
  - 2. VOC Content: Not more than 250 g/L, excluding water.
- P. Fume Hood Exhaust: 2 inch w.g. pressure class, stainless steel, fully welded.

## 2.03 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
- B. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide turning vanes. .
- D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- E. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA HVAC Duct Construction Standards.

- F. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Joints shall be minimum 4 inch cemented slip joint, brazed or electric welded. Prime coat welded joints.
- G. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.
- H. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

## 2.04 MANUFACTURED DUCTWORK AND FITTINGS

- A. Manufacture in accordance with SMACNA HVAC Duct Construction Standards Metal and Flexible, and as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Double Wall Insulated Round Ducts: Round spiral lockseam duct with paintable galvanized steel outer wall, perforated galvanized steel inner wall; fitting with solid inner wall. Provide paint in color selected by architect.
  - 1. Manufacture in accordance with SMACNA HVAC Duct Construction Standards.
  - 2. Insulation:
    - a. Thickness: 2 inch.
    - b. Material: Fiberglass, with mylar coating between insulation and perforated liner.
- C. Transverse Duct Connection System: SMACNA "J" rated rigidly class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.

#### 2.05 CASINGS

- A. Fabricate casings in accordance with SMACNA HVAC Duct Construction Standards and construct for operating pressures indicated.
- B. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of 18 gage galvanized expanded metal mesh supported at 12 inch centers, turned up 12 inches at sides with sheet metal shields.
- C. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of 18 gage galvanized expanded metal mesh supported at 12 inch centers, turned up 12 inches at sides with sheet metal shields.
- D. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection.
  - 1. Provide clear wire glass observation ports, minimum 6 X 6 inch size.

# PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA HVAC Duct Construction Standards.
- B. Install in accordance with manufacturer's instructions.
- C. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- D. Install and seal metal and flexible ducts in accordance with SMACNA HVAC Duct Construction Standards Metal and Flexible.
- E. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with

spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

- F. Provide flexible duct connectors at all connections between ducts and motorized equipment.
- G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- H. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.
- I. Use double nuts and lock washers on threaded rod supports.
- J. Tape joints of PVC coated metal ductwork with PVC tape.
- K. Connect terminal units to supply ducts with one foot maximum length of flexible duct. Do not use flexible duct to change direction.
- L. Connect diffusers or light troffer boots to low pressure ducts with 5 feet maximum length of flexible duct held in place with strap or clamp.
- M. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- N. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
- O. Use stainless steel for ductwork exposed to view and stainless steel or carbon steel for ducts where concealed.
- P. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- Q. At exterior wall louvers, seal duct to louver frame and install blank-out panels as required.

## 3.02 TESTING

- A. Conduct required duct-leakage testing as defined within this specification and otherwise noted in the contract documents.
- B. Duct-leakage testing is mandatory for ALL duct systems, of all pressure classes.

## 3.03 SCHEDULES

- A. Ductwork Material:
  - 1. Low Pressure Supply (Heating Systems): Steel, Aluminum.
  - 2. Low Pressure Supply (System with Cooling Coils): Steel, Aluminum.
  - 3. Medium and High Pressure Supply: Steel.
  - 4. Return and Relief: Steel, Aluminum.
  - 5. General Exhaust: Steel, Aluminum.
  - 6. Kitchen Hood Exhaust: Carbon Steel, Stainless Steel.
  - 7. Fume Hood Exhaust: Stainless Steel.
  - 8. Outside Air Intake: Steel.
  - 9. Exposed round ductwork: Double-walled spiral.
- B. Ductwork Pressure Class:
  - 1. Supply (Heating Systems): 1 inch
  - 2. Supply (System with Cooling Coils): 1 inch.
  - 3. Return and Relief: 1 inch.
  - 4. General Exhaust: 2.
  - 5. Fume Hood Exhaust: 2 inch.
  - 6. Outside Air Intake: 2 inch.

## END OF SECTION

THIS PAGE MILINION MILLING MAIL

# SECTION 23 33 00 AIR DUCT ACCESSORIES

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Air turning devices/extractors.
- B. Backdraft dampers metal.
- C. Backdraft dampers.
- D. Combination fire and smoke dampers.
- E. Duct access doors.
- F. Duct test holes.
- G. Fire dampers.
- H. Flexible duct connections.
- I. Smoke dampers.
- J. Volume control dampers.

#### 1.02 RELATED REQUIREMENTS

- A. Section 22 05 48 Vibration and Seismic Controls for Plumbing Piping and Equipment.
- B. Section 23 31 00 HVAC Ducts and Casings.
- C. Section 23 36 00 Air Terminal Units: Pressure regulating damper assemblies.
- D. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

## 1.03 REFERENCE STANDARDS

- A. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems.
- B. NFPA 92 Standard for Smoke Control Systems.
- C. NFPA 92A Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences.
- D. SMACNA (DCS) HVAC Duct Construction Standards Metal and Flexible.
- E. UL 33 Safety Heat Responsive Links for Fire-Protection Service.
- F. UL 555 Standard for Fire Dampers.
- G. UL 555S Standard for Smoke Dampers.

## 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide for shop fabricated assemblies including volume control dampers, duct access doors, duct test holes, and hardware used. Include electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers, duct access doors, and duct test holes.
- D. Manufacturer's Installation Instructions: Provide instructions for fire dampers and combination fire and smoke dampers.

#### 1.05 PROJECT RECORD DOCUMENTS

A. Record actual locations of access doors and test holes.

#### 1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum five years of documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

## 1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect dampers from damage to operating linkages and blades.

## 1.08 EXTRA MATERIALS

- A. See Section 01 60 00 Product Requirements, for additional provisions.
- B. Provide two of each size and type of fusible link.

## PART 2 PRODUCTS

## 2.01 AIR TURNING DEVICES/EXTRACTORS

- A. Manufacturers:
  - 1. Krueger: www.krueger-hvac.com.
  - 2. Ruskin Company: www.ruskin.com.
  - 3. Titus: www.titus-hvac.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Multi-blade device with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps.

## 2.02 BACKDRAFT DAMPERS - METAL

## 2.03 BACKDRAFT DAMPERS

- A. Manufacturers:
  - 1. Louvers & Dampers, Inc: www.louvers-dampers.com.
  - 2. Nailor Industries Inc: www.nailor.com.
  - 3. Ruskin Company: www.ruskin.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Gravity Backdraft Dampers, Size 18 x 18 inches or Smaller, Furnished with Air Moving Equipment: Air moving equipment manufacturer's standard construction.

## 2.04 BACKDRAFT DAMPERS - FABRIC

- A. Fabric Backdraft Dampers: Factory-fabricated, 18 gage, galvanized steel frame.
  - 1. Blades: Neoprene coated fabric material.
  - 2. Birdscreen: 1/2 inch nominal mesh of galvanized steel or aluminum.
  - 3. Maximum Velocity: 1000 fpm (5 m/sec) face velocity.
- B. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: galvanized steel or extruded aluminum, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

## 2.05 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers:
  - 1. Louvers & Dampers, Inc: www.louvers-dampers.com.
  - 2. Nailor Industries Inc: www.nailor.com.
  - 3. Ruskin Company: www.ruskin.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C. Provide factory sleeve and collar for each damper.
- D. Multiple Blade Dampers: Fabricate with 16 gage galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel

jamb seals, 1/8 x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.

- E. Operators: UL listed and labelled spring return electric type suitable for 120 volts, single phase, 60 Hz. Locate damper operator on interior of duct and link to damper operating shaft.
- F. Normally Closed Smoke Responsive Fire Dampers: Curtain type, opening by gravity upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure.
- G. Normally Open Smoke Responsive Fire Dampers: Curtain type, closing upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure, stainless steel springs with locking devices to ensure positive closure for units mounted horizontally.
- H. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

#### 2.06 DUCT ACCESS DOORS

- A. Manufacturers:
  - 1. Nailor Industries Inc: www.nailor.com.
  - 2. Ruskin Company: www.ruskin.com.
  - 3. SEMCO Incorporated: www.semcoinc.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
- C. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, install minimum 1 inch thick insulation with sheet metal cover.
  - 1. Less Than 12 inches Square: Secure with sash locks.
  - 2. Up to 18 inches Square: Provide two hinges and two sash locks.
  - 3. Up to 24 x 48 inches: Three hinges and two compression latches with outside and inside handles.
  - 4. Larger Sizes: Provide an additional hinge.
- D. Access doors with sheet metal screw fasteners are not acceptable.

#### 2.07 DUCT TEST HOLES

- A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

#### 2.08 FIRE DAMPERS

- A. Manufacturers:
  - 1. Louvers & Dampers, Inc: www.louvers-dampers.com.
  - 2. Nailor Industries Inc: www.nailor.com.
  - 3. Ruskin Company: www.ruskin.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- C. Ceiling Dampers: Galvanized steel, 22 gage frame and 16 gage flap, two layers 0.125 inch ceramic fiber on top side and one layer on bottom side for round flaps, with locking clip.
- D. Horizontal Dampers: Galvanized steel, 22 gage frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket.

- E. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations or closure under air flow conditions. Configure with blades out of air stream except for 1.0 inch pressure class ducts up to 12 inches in height.
- F. Multiple Blade Dampers: 16 gage galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
- G. Fusible Links: UL 33, separate at 160 degrees F with adjustable link straps for combination fire/balancing dampers.

#### 2.09 FLEXIBLE DUCT CONNECTIONS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
- B. Flexible Duct Connections: Fabric crimped into metal edging strip.
  - 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd.
    - a. Net Fabric Width: Approximately 6 inches wide.
  - 2. Metal: 3 inches wide, 24 gage thick galvanized steel.
- C. Leaded Vinyl Sheet: Minimum 0.55 inch thick, 0.87 lbs per sq ft, 10 dB attenuation in 10 to 10,000 Hz range.

#### 2.10 SMOKE DAMPERS

- A. Manufacturers:
  - 1. Louvers & Dampers, Inc: www.louvers-dampers.com.
  - 2. Nailor Industries Inc: www.nailor.com.
  - 3. Ruskin Company: www.ruskin.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Fabricate in accordance with NFPA 90A and UL 555S, and as indicated.
- C. Dampers: UL Class 1 multiple blade type fire damper, normally closed automatically operated by electric actuator.
- D. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

## 2.11 VOLUME CONTROL DAMPERS

- A. Manufacturers:
  - 1. Louvers & Dampers, Inc: www.louvers-dampers.com.
  - 2. Nailor Industries Inc: www.nailor.com.
  - 3. Ruskin Company: www.ruskin.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
- C. Splitter Dampers:
  - 1. Material: Same gage as duct to 24 inches size in either direction, and two gages heavier for sizes over 24 inches.
  - 2. Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.
  - 3. Operator: Minimum 1/4 inch diameter rod in self aligning, universal joint action, flanged bushing with set screw .
- D. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.

- E. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
- F. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
- G. Quadrants:
  - 1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
  - 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

#### PART 3 EXECUTION

#### 3.01 PREPARATION

A. Verify that electric power is available and of the correct characteristics.

#### 3.02 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards. Refer to Section 23 31 00 for duct construction and pressure class.
- B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- C. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated. Provide 4 x 4 inch for balancing dampers only. Review locations prior to fabrication.
- D. Provide duct test holes where indicated and required for testing and balancing purposes.
- E. Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- F. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.
  - 1. Smoke dampers shall be integrated into the "smoke purge control system". Dampers in the return ductwork shall be overridden to the open position when the smoke purge is activated.
- G. Demonstrate re-setting of fire dampers to Caesar Rodney School District's representative.
- H. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- I. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment; see Section 22 05 48.
- J. For fans developing static pressures of 5.0 inches and over, cover flexible connections with leaded vinyl sheet, held in place with metal straps.
- K. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.
- L. Use splitter dampers only where indicated.
- M. Provide balancing dampers on high velocity systems where indicated. Refer to Section 23 36 00 Air Terminal Units.

N. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly. END OF SECTION

# SECTION 23 34 23 HVAC POWER VENTILATORS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Roof ventilators.
- B. Wall exhausters.
- C. Inline centrifugal fans.
- D. Ceiling exhaust fans.
- E. Dryer exhaust systems.
- F. Laboratory and fume exhaust.

# 1.02 RELATED REQUIREMENTS

- A. Section 23 05 13 Common Motor Requirements for HVAC Equipment.
- B. Section 23 05 48 Vibration and Seismic Controls for HVAC Piping Equipment.
- C. Section 23 33 00 Air Duct Accessories: Backdraft dampers.
- D. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections.

# 1.03 REFERENCE STANDARDS

- A. AMCA 99 Standards Handbook.
- B. AMCA 204 Balance Quality and Vibration Levels for Fans.
- C. AMCA 210 Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
- D. AMCA 260 Laboratory Methods of Testing Induced Flow Fans for Rating.
- E. AMCA (DIR) [Directory of] Products Licensed Under AMCA International Certified Ratings Program; Air Movement and Control Association International, Inc..
- F. AMCA 300 Reverberant Room Method for Sound Testing of Fans.
- G. AMCA 301 Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- H. ANSI Z9.5 Laboratory Ventilation.
- I. NEMA MG 1 Motors and Generators.
- J. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- K. NFPA 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- L. UL 705 Power Ventilators.

## 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Indicate installation instructions.
- D. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

#### 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum 5 years of documented experience.
- B. Kitchen Range Hood Exhaust Fans: Comply with requirements of NFPA 96.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

#### 1.06 FIELD CONDITIONS

A. Permanent ventilators may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation.

#### 1.07 EXTRA MATERIALS

- A. See Section 01 60 00 Product Requirements, for additional provisions.
- B. Supply two sets of belts for each fan.

#### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Greenheck: www.greenheck.com.
- B. Loren Cook Company: www.lorencook.com.
- C. PennBarry: www.pennbarry.com.
- D. American Coolair/ILG: www.coolair.com
- E. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 POWER VENTILATORS - GENERAL

- A. Static and Dynamically Balanced: AMCA 204 Balance Quality and Vibration Levels for Fans.
- B. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
- C. Sound Ratings: AMCA 301, tested to AMCA 300, and bearing AMCA Certified Sound Rating Seal.
- D. Fabrication: Conform to AMCA 99.
- E. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

#### 2.03 ROOF VENTILATORS

- A. Product Requirements:
  - 1. Performance Ratings: Determined in accordance with AMCA 210.
  - 2. Sound Ratings: AMCA 301, tested to AMCA 300.
  - 3. Fabrication: Conform to AMCA 99.
  - 4. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.
- B. Performance and Model: As indicated on drawings.1. Motor: Refer to Section 23 05 13.
- C. Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.

- D. Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
- E. Roof Curb: 20 inch high of galvanized steel with continuously welded seams, factory installed nailer strip.
- F. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor
- G. Shunt Trip Breakers: Provide for each fan of 2,000 CFM or greater for interlock with Fire Alarm system.
- H. Backdraft Damper: Motor actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.
- I. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

#### 2.04 WALL EXHAUSTERS

- A. Performance: As indicated on drawings.
  - 1. Motor: Refer to Section 23 05 13..
- B. Fan Unit: V-belt or direct driven with spun aluminum housing; resiliently mounted motor; 1/2 inch mesh, 0.062 inch thick aluminum wire bird screen.
- C. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.
- D. Backdraft Damper: Motor actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.
- E. Sheaves: For V-belt drives, provide cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

## 2.05 CABINET AND CEILING EXHAUST FANS

- A. Performance: As Indicated on drawings.
  - 1. Motor: Refer to Section 23 05 13.
- B. Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resilient mounted motor, motorized backdraft damper in discharge.
- C. Disconnect Switch: Cord and plug in housing for thermal overload protected motor .
- D. Grille: Molded white plastic or Aluminum with baked white enamel finish.
- E. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

## 2.06 INLINE CENTRIFUGAL FANS

- A. Manufacturers:
  - 1. Greenheck Fan Corporation: www.greenheck.com.
  - 2. Loren Cook Company: www.lorencook.com.
  - 3. PennBarry, Division of Air System Components: www.pennbarry.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resilient mounted motor, motorized damper in discharge.
- C. Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted switch.

D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

# 2.07 DRYER EXHAUST SYSTEMS

- A. Manufacturers:
  - 1. LaundryFab: www.laundryfab.com.
  - 2. US Draft: www.usdraftco.com.
  - 3. Substitutions: See Section 01 60 00 Product Requirements.
- B. Performance Ratings: See Drawings.
- C. Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resilient mounted motor, motorized damper in discharge.
- D. Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted switch.
- E. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.
- F. Drive: ECM.
- G. Controls: Provide a Laundry Exhaust System (LES) to maintain constant pressure in the laundry exhaust ductwork. The LES shall utilize bi-directional pressure transducer and PID technology to rapidly respond to varying manifold pressures due to load changes in the laundry exhaust system. Utilizing the MEF Multi-use Exhaust Fan and an L-series controller, the system shall receive a start signal through a current sensing relay at the associated dryer.

## 2.08 LABORATORY AND FUME EXHAUST

- A. Manufacturers:
  - 1. MK Plastics.
  - 2. Strobic Air.
  - 3. Greenheck.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. General Requirements:
  - 1. Provide fan types tested in accordance with AMCA 210, AMCA 260 (Induced Flow Fans) and AMCA 300 in an AMCA-accredited laboratory.
- C. Fan Assemblies:
  - 1. Provide unit suitable for maintaining structural integrity and operation in 125 mph wind without external guy wires or supplemental supports when mounted on manufacturer-supplied roof curbs.
- D. Belt Drive Fan:
  - 1. Fan Wheel:
    - a. Type: Non-overloading, backward inclined centrifugal.
    - b. Material: Aluminum.
  - 2. Statically and dynamically balanced.
  - 3. Motors:
    - a. Open drip-proof (ODP).
    - b. Heavy duty ball bearing type.
    - c. Mount on vibration isolators or resilient cradle mounts, out of air stream.
    - d. Fully accessible for maintenance.
  - 4. Housing:

- a. Construct of heavy gage aluminum including curb cap, windband, and motor compartment.
- b. Rigid internal support structure.
- c. One-piece fabricated or fully welded curb-cap base to windband for leak proof construction.
- d. Construct drive frame assembly of heavy gage steel, mounted on vibration isolators.
- e. Provide breather tube for fresh air motor cooling and wiring.
- E. Shafts and Bearings:
  - 1. Fan Shaft:
    - a. Ground and polished steel with anti-corrosive coating.
    - b. First critical speed at least 25 percent over maximum cataloged operating speed.
  - 2. Bearings:
    - a. Permanently sealed or pillow block type.
    - b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
    - c. 100 percent factory tested.
- F. Drive Assembly:
  - 1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
  - 2. Belts: Static free and oil resistant.
  - 3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
  - 4. Motor pulley adjustable for final system balancing.
  - 5. Readily accessible for maintenance.
- G. Disconnect Switches:
  - 1. Factory mounted and wired.
  - 2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Outdoor Locations: Type 3R.
  - 3. Finish for Painted Steel Enclosures: Provide manufacturer's standard or factory applied gray unless otherwise indicated.
  - 4. Positive electrical shutoff.
  - 5. Wired from fan motor to junction box installed within motor compartment.
- H. High Plume Discharge Nozzle with Integral Windband:
  - 1. Provide combination discharge nozzle and windband to induce ambient airflow from outside fan housing and increase discharge velocities to velocities that comply with ANSI Z9.5, minimum 3,000 fpm.
  - 2. Provide a windband with a minimum of 120 inches discharge height above the roof surface.
  - 3. Provide a discharge nozzle that develops a maximum discharge air velocity of 9,500 fpm.
  - 4. Provide sound attenuated windband with integral closed-cell foam that does not increase overall height of fan system.
  - 5. Provide drain connection at lowest point of housing.
- I. Roof Curb: 20 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips, insulation and curb bottom, curb bottom, ventilated double wall, and factory installed nailer strip.
- J. Mounting Base: Provide mounting base with lifting lugs.
- K. Mixing Plenum Box: Designed to secure fans for wind loads up to 125 mph, mixing plenum box features modular construction allowing for multiple configurations and retrofit installation.
  - 1. Match fan housing material of construction, to include integral duct flange to mate to fan inlet.

- 2. Provide bottom intake mixing plenum box for attachment of building duct.
- 3. Mount mixing box on heavy duty roof curb.
- 4. Provide insulated mixing box with stainless steel liner.
- 5. Provide flow straighteners.
- L. Isolation Dampers:
  - 1. Parallel blade design, constructed of 304 stainless steel.
  - 2. Provide 24 volt-powered, modulating actuator, rated for NEMA 250, Type 2 (IP54) environment, to coordinate with fan operation.
- M. Bypass Dampers:
  - 1. Provide modulating bypass damper to maintain fan discharge velocity.
  - 2. Provided opposed blade design, constructed of 304 stainless steel.
  - 3. Provide 24 volt-powered, modulating actuator, rated for NEMA 250, Type 2 (IP54) environment, to coordinate with fan operation.
- N. Piezometer Ring: Provide piezometer ring type differential pressure device with connections for field-installed flow measuring instrumentation.
  - 1. Pressure Transducer without Display: Provide piezometer ring and transducer to convert differential pressure readings to 4 20 mA DC signal proportional to flow.
  - 2. Pressure Transducer/Transmitter with Display:
    - a. Provide piezometer ring and transducer with local digital display to convert differential pressure readings to 4 20 mA DC signal proportional to flow. Include two independently adjustable SPDT dry-contact outputs.
- O. Options/Accessories:
  - 1. Automatic Belt Tensioner: Automatic device that adjusts for correct belt tension for single drives.
  - 2. Inlet Safety Screen: Welded wire safety screens fabricated for easy installation and removal.
  - 3. Birdscreen: Galvanized steel construction for fan discharge protection.
  - 4. Dampers: Provide motorized type.
  - 5. Drain Connection:
    - a. Aluminum construction.
    - b. Allows single-point drainage of grease, water, or other residues.
  - 6. Heat Baffle: Prevents heat from radiating into motor compartment.
  - 7. Tie-down Points: Four brackets located on windband secures fan in heavy wind applications.
  - 8. External motor speed controllers for field mounting.

## PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof or wall exhausters with aluminum lag screws to roof curb or structure.
- C. Extend ducts to roof or wall exhausters into roof curb or structure. Counterflash duct to roof or wall opening.
- D. Hung Cabinet Fans:
  - 1. Install fans with resilient mountings and flexible electrical leads. Refer to Section 23 05 48.
  - 2. Install flexible connections specified in Section 23 33 00 between fan and ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- E. Provide sheaves required for final air balance.
- F. Install backdraft dampers on inlet to roof and wall exhausters.

- G. Provide backdraft dampers on outlet from cabinet and ceiling exhauster fans and as indicated.
- H. Provide fans with junction box and wire whip connected to associated motorized backdraft damper to open damper upon activation of exhaust fan.

## END OF SECTION

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# SECTION 23 37 00 AIR OUTLETS AND INLETS

## PART 1 GENERAL

## **1.01 SECTION INCLUDES**

- A. Diffusers.
- B. Registers/grilles.
- C. Door grilles.
- D. Louvers.
- E. Goosenecks.

## 1.02 RELATED REQUIREMENTS

A. Section 09 90 00 - Painting and Coating: Painting of ducts visible behind outlets and inlets.

## 1.03 REFERENCE STANDARDS

- A. AMCA 500-L Laboratory Methods of Testing Louvers for Rating.
- B. ARI 890 Standard for Air Diffusers and Air Diffuser Assemblies; Air-Conditioning and Refrigeration Institute.
- C. ASHRAE Std 70 Method of Testing the Performance of Air Outlets and Inlets.
- D. SMACNA (DCS) HVAC Duct Construction Standards Metal and Flexible.

## 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements for submittal procedures.
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- C. Samples: Submit one of each required air outlet and inlet type.
- D. Project Record Documents: Record actual locations of air outlets and inlets.

## 1.05 QUALITY ASSURANCE

- A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B. Test and rate louver performance in accordance with AMCA 500-L.

## 1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum five years of documented experience.

## 1.07 MOCK-UP

- A. Provide mock-up of typical interior or exterior ceiling module with supply and return air outlets.
- B. Locate where directed.
- C. Mock-up may remain as part of the Work.

## PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Carnes Company HVAC: www.carnes.com.
- B. Krueger: www.krueger-hvac.com.
- C. Price Industries: www.price-hvac.com.
- D. Titus: www.titus-hvac.com.

- E. Tuttle and Bailey: www.tuttleandbailey.com.
- F. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 RECTANGULAR CEILING DIFFUSERS

- A. Type: Square, stamped, multi-core diffuser to discharge air in 360 degree, one way, two way, three way or four way pattern as shown on drawings and with sectorizing baffles where indicated.
- B. Frame: Surface mount or inverted T-bar as indicated on drawings. In plaster ceilings, provide plaster frame and ceiling frame.
- C. Color: As selected by StudioJAED from manufacturer's standard range.
- D. Fabrication: Aluminum with baked enamel off-white finish.
- E. Accessories: Radial opposed blade damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

#### 2.03 PERFORATED FACE CEILING DIFFUSERS

- A. Type: Perforated face with fully adjustable pattern and removable face.
- B. Frame: Surface mount or Inverted T-bar as indicated on drawings. In plaster ceilings, provide plaster frame and ceiling frame.
- C. Color: As selected by StudioJAED from manufacturer's standard range.
- D. Fabrication: Aluminum or aluminum frame and baked enamel off-white finish.
- E. Accessories: Radial opposed blade damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

#### 2.04 CEILING SLOT DIFFUSERS

- A. Fabrication: Aluminum extrusions with factory clear lacquer finish.
- B. Color: To be selected by StudioJAED from manufacturer's standard range.
- C. Frame: 1-1/4 inch margin with countersunk screw mounting and gasket, mitered end border.
- D. Plenum: Integral, galvanized steel, insulated.

## 2.05 CEILING SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, two-way deflection.
- B. Frame: 1 inch margin with countersunk screw mounting and gasket.
- C. Fabrication: Aluminum extrusions with factory off-white enamel or prime coat finish as indicated on drawings or selected by architect.
- D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

## 2.06 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, horizontal face.
- B. Frame: 1 inch margin with countersunk screw mounting.
- C. Color: To be selected by StudioJAED from manufacturer's standard range.
- D. Fabrication: Aluminum extrusions, with factory off-white enamel, baked enamel, or prime coated finish as indicated on drawings or selected by architect.
- E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

F. Gymnasiums and Training Rooms: Provide front pivoted or welded in place blades, securely fastened to be immobile.

## 2.07 CEILING GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Fixed grilles of  $1/2 \times 1/2 \times 1/2$  inch louvers.
- B. Fabrication: Acrylic plastic with off-white finish.
- C. Frame: Channel lay-in frame for suspended grid ceilings.
- D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

#### 2.08 WALL SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined and individually adjustable blades, 3/4 inch minimum depth, 3/4 inch maximum spacing with spring or other device to set blades, horizontal face, double deflection.
- B. Frame: 1 inch margin with countersunk screw mounting and gasket.
- C. Color: To be selected by StudioJAED from manufacturer's standard range.
- D. Fabrication: Aluminum extrusions, with factory off-white enamel, baked enamel, prime coat or clear lacquer finish as indicated on drawings or selected by architect.
- E. Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.
- F. Gymnasiums: Provide front pivoted or welded in place blades, securely fastened to be immobile.

#### 2.09 WALL EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with spring or other device to set blades, horizontal face.
- B. Frame: 1 inch margin with countersunk screw mounting.
- C. Color: To be selected by StudioJAED from manufacturer's standard range.
- D. Fabrication: Aluminum extrusions, with factory off-white enamel, baked enamel, prime coated or clear lacquer finish as indicated on drawings or selected by architect.
- E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.
- F. Gymnasiums: Provide front pivoted or welded in place blades, securely fastened to be immobile.

#### 2.10 WALL GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Fixed grilles of  $1/2 \times 1/2 \times 1/2$  inch louvers.
- B. Fabrication: Aluminum with factory clear lacquer, off-white enamel or baked enamel finish as indicated on drawings or selected by architect.
- C. Frame: 1 inch margin with countersunk screw mounting.
- D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

## 2.11 DOOR GRILLES

- A. Type: V-shaped louvers of 20 gage thick steel, 1 inch deep on 1/2 inch centers.
- B. Frame: 20 gage steel with auxiliary frame to give finished appearance on both sides of door, with factory prime coat finish.

## 2.12 LOUVERS

- A. Type: 4 inch or 6 inch deep as indicated on drawings with blades on 45 degree slope , heavy channel frame, 1/2 inch square mesh screen over exhaust and 1/2 inch square mesh screen over intake.
- B. Color: To be selected by StudioJAED from manufacturer's standard range. Provide Kynar / Hylar 500 finish.
- C. Fabrication: 12 gage thick extruded aluminum, welded assembly, with factory prime coat, baked enamel, anodized or fluoropolymer spray finish as indicated on drawings or selected by architect.
- D. Mounting: Furnish with exterior angle flange, screw holes in jambs or masonry strap anchors for installation.

#### 2.13 GOOSENECKS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards of minimum 18 gage stainless steel.
- B. Mount on minimum 12 inch high curb base where size exceeds 4x4 inch.

## PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- C. Install diffusers to ductwork with air tight connection.
- D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- E. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 90 00.

## 3.02 AIR OUTLET AND INLET SCHEDULE

A. See Drawings

## END OF SECTION

# SECTION 23 51 00 BREECHINGS, CHIMNEYS, AND STACKS

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

A. Manufactured breechings.

## 1.02 RELATED REQUIREMENTS

- A. Section 07 84 00 Firestopping.
- B. Section 23 05 13 Motor Requirements for HVAC and Plumbing Equip: Induced draft fan motor.

## 1.03 REFERENCE STANDARDS

- A. ANSI Z21.66 American National Standard for Automatic Vent Damper Devices for Use with Gas-Fired Appliances.
- B. ASME B16.5 Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard.
- C. ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges.
- D. ASME B31.9 Building Services Piping.
- E. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- F. ASTM A181/A181M Standard Specification for Carbon Steel Forgings, for General Purpose Piping.
- G. ASTM A193/A193M Standard Specification for Alloy Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
- H. ASTM A194/A194M Standard Specification for Carbon and Alloy Nuts for Bolts for High Pressure or High Temperature Service, or Both.
- I. ASTM A234/A234M Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- J. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- K. ASTM A1011/A1011M Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
- L. ASTM C401 Standard Classification of Alumina and Alumina-Silicate Castable Refractories.
- M. MSS SP-58 Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation.
- N. NEMA MG 1 Motors and Generators.
- O. NFPA 31 Standard for the Installation of Oil Burning Equipment.
- P. NFPA 54 National Fuel Gas Code.
- Q. NFPA 70 National Electrical Code.
- R. NFPA 82 Standard on Incinerators and Waste and Linen Handling Systems and Equipment.
- S. NFPA 211 Guide for Smoke and Heat Venting.
- T. SMACNA (DCS) HVAC Duct Construction Standards Metal and Flexible.
- U. UL 103 Factory-Built Chimneys for Residential Type and Building Heating Appliances.

- V. UL 127 Standard for Factory-Built Fireplaces.
- W. UL 378 Standard for Draft Equipment.
- X. UL 641 Type L Low Temperature Venting Systems.
- Y. UL 959 Medium Heat Appliance Factory Built Chimneys.

## 1.04 DEFINITIONS

- A. Breeching: Vent Connector.
- B. Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
- C. Smoke Pipe: Round, single wall vent connector.
- D. Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.
- E. Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device.

## **1.05 DESIGN REQUIREMENTS**

A. Factory built vents and chimneys used for venting natural draft appliances shall comply with NFPA 211 and be UL listed and labeled.

## 1.06 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate the installation of breeching and venting with size, location and installation of service utilities.
- B. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- C. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

## 1.07 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate general construction, dimensions, weights, support and layout of breechings. Submit layout drawings indicating plan view and elevations where factory built units are used.

## 1.08 QUALITY ASSURANCE

- A. Designer Qualifications: Design stacks under direct supervision of a Professional Structural Engineer experienced in design of the type of work specified and licensed in Delaware.
- B. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

## 1.09 REGULATORY REQUIREMENTS

- A. Conform to applicable code for installation of natural gas burning appliances and equipment.
- B. Conform to NFPA 31 for installation of oil burning appliances and equipment.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

## PART 2 PRODUCTS

## 2.01 MANUFACTURERS

A. Pro Tech; Model FasNSeal: www.ampcostacks.com.

- B. Metal-Fab, Inc; Model Corr / Guard: www.mtlfab.com.
- C. Selkirk Corporation; Model Saf T Vent: www.selkirkcommercial.com.

#### 2.02 MANUFACTURED BREECHINGS

- A. The following breeching shall be provided for water heater exhaut and dryer exhaust.
- B. Provide factory-built, double-wall stainless steel / AL29-4C, manufacturered exhaust breeching, tested to UL-1738 with positive pressure rating. Include locking band and integral gasket for a factory-approved assembled system.
- C. Assembly to be UL listed for use with building equipment in compliance with NFPA 211.
- D. Size in accordance with equipment manufacturer's recommendations and fabricator requirements.
- E. Fabricate with 1 inch minimum air space between walls and construct inner liner of aluminized stainless steel and outer jacket of 304 stainless steel.
  - 1. Protect aluminized steel surfaces exposed to the elements with a minimum of one base coat of primer and one finish coat of corrosion resistant paint suitable for outer jacket skin temperatures of the application.
- F. Design, fabricate, and install gas-tight preventing products of combustion leaking into the building.
  - 1. Securely connect inner joints and seal with factory supplied overlapping V-bands and appropriate sealant in accordance with manufacturer's instructions.
  - 2. System design to compensate for all flue gas induced thermal expansion.

#### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Route breeching condensate drain through acid neutralizer and to nearest area drain or condensate collector.
- C. Install in accordance with NFPA 54.
- D. Install breechings with minimum of joints. Align accurately at connections, with internal surfaces smooth.
- E. Support breechings from building structure, rigidly with suitable ties, braces, hangers and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12 foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA HVAC Duct Construction Standards for equivalent duct support configuration and size.
- F. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.
- G. Clean breechings, chimneys, and stacks during installation, removing dust and debris.
- H. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of breechings, breeching insulation, chimneys, or stacks.

## END OF SECTION

THIS PAGE MILINION MILLING MAIL

# SECTION 23 72 23 PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Energy recovery units.
- B. Casing.
- C. Fans.
- D. Filters.
- E. Dampers.
- F. Vibration isolation.
- G. Roof curbs.
- H. Power and controls.
- I. Accessories.
- J. Service accessories.

## 1.02 RELATED SECTIONS

- A. Section 01 91 00 Commissioning
- B. Section 01 91 10 Functional Testing Procedures
- C. Section 23 08 00 Mechanical Systems Commissioning
- D. Section 23 08 10 Control Systems Commissioning

## 1.03 REFERENCE STANDARDS

- A. AHRI 1060 I-P Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment.
- B. ASHRAE Std 52.2 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- C. ASHRAE Std 84 Method of Testing Air to Air Heat/Energy Exchangers.
- D. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- E. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.
- F. NFPA 70 National Electrical Code.
- G. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems.
- H. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials
- I. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials.

## 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Manufacturer's installation instruction, product data, and engineering calculations.
- C. Shop Drawings: Show design and assembly of energy recovery unit and installation and connection details.
- D. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.

2. Spare Parts: One spare set of filters.

## 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
  - 1. Firm regularly engaged in manufacturing energy recovery units.
  - 2. Products in satisfactory use in similar service for not less than five years.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store in manufacturer's unopened packaging.
- B. Store products to be installed indoors in dry, heated area.

#### 1.07 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Warranty energy recovery media (static core or wheel) to be free from defects in material and workmanship for 10 years under circumstances of normal use.
- C. Warranty motor to be free from defects in material and workmanship for 7 years under circumstances of normal use.

## PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Energy Recovery Ventilators:
  - 1. Renew Aire: www.renewaire.com.
  - 2. Nu-Air: www.nu-air.com
  - 3. Innovent: www.innoventair.com
  - 4. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 ENERGY RECOVERY UNITS

- A. Energy Recovery Units: Fixed plate cross-flow energy exchange type (hydroscopic resin) type; prefabricated packaged system designed by manufacturer.
  - 1. Access: Hinged access panels on front. Pressure taps provided.
  - 2. Lifting holes at the unit base.
  - 3. Permanent name plate listing manufacturer mounted inside door near electrical panel.

## 2.03 CASING

- A. Wall, Floor, and Roof Panels:
  - 1. Construction: 1 inch thick, double wall box construction, with formed edges of exterior wall overlapping formed edges of interior wall.
  - 2. Exterior Wall: galvanized steel sheet. or aluminum.
    - a. 20 gage galvanized steel,
    - b. Color: Gray or white
  - 3. Interior Wall: Galvanized sheet metal.
    - a. 24 gage galvanized sheet metal.
  - 4. Insulation:
    - a. 1 inch insulated fiberglass board insulation.
    - b. Flame Spread Index: 25, maximum, when tested in accordance with ASTM E84, NFPA 255, and UL 723.
    - c. Smoke Developed Index: 50, maximum, when tested in accordance with ASTM E84, NFPA 255, and UL 723.
  - 5. Roof Panel: Weatherproof.
  - 6. Panel Joints: 20 gauge steel with lapped corners and zinc-plated screws.
  - 7. Fasteners: Stainless steel.

- 8. Isolation and Seal: Form continuous, thermally isolated, weather tight seal between inner wall of panels and structural framing with closed cell PVC foam gasketing.
- 9. Seams: Sealed, requiring no caulking at job site.
- 10. Coating: Polyurethane enamel.
- B. Access Panels: Provide access to components through a large, tightly sealed and easily removable panel.
- C. Doors:
  - 1. Construct doors of same construction and thickness as wall panels.
  - 2. Hardware:
    - a. Hinges: Aluminum.
    - b. Corrosion-resistant.
    - c. Provide exterior handle and interior 3-point latching device.
    - d. Prop Rod: Capable of propping doors in open position.
    - e. Wind Restraint: Door chain with spring to absorb force of door swinging open.
    - f. Gasket: P-shaped extruded neoprene.
    - g. Label each door to identify equipment located within.
- D. Trim: 0.08 inches aluminum, continuously welded.
- E. Install panels on structural framing with self-tapping stainless steel screws with integral neoprene-backed stainless steel washers.
- F. Duct Connection Collars: 0.08 inches aluminum, continuously welded.
- G. Weather Hood: Provide on fresh air inlet and exhaust air outlet; removable for access.
  - 1. Construction: ASTM A653/A653M, G90/Z275 galvanized, 20 gage, 0.0359 inch steel sheet.
  - 2. Screening: Expanded aluminum bird screen.
  - 3. Fresh Air Weather Hood: Maintain a face velocity less than 340 feet/min.

#### 2.04 FANS

- A. Provide separate fans for exhaust and supply blowers.
- B. Fans:
  - 1. Individually driven with a dedicated motor.
  - 2. AMCA-rated.
  - 3. Provide with non-overloading characteristics.
  - 4. Provide with vibration isolator base.
- C. Bearings:
  - 1. Pillow block.
  - 2. Bearings: Permanently lubricated sealed ball bearings.
  - 3. Rated for not less than 200,000 hours of operation with accessible greased fittings.
- D. Housings: 12 gage aluminized steel with plenums integral to general housing and constructed to Class 1 fan standards.
- E. Motors:
  - 1. Motors: VFD-driven as scheduled.
  - 2. Efficiency: Premium.
  - 3. Speed: Variable.
  - 4. Control: Variable Frequency Drive.
  - 5. Fan Motor: Thermal overload protected.
  - 6. Fan Motor: UL listed and labeled.
- F. Drives:
  - 1. Fans: Belt driven or direct as scheduled.

- 2. Sheaves: Variable.
- 3. Service Factor: 1.2.
- G. Belt Guards: Full sized, hinged, painted with high-visibility safety color, and accessible with standard tools.

#### 2.05 TOTAL ENERGY RECOVERY MEDIA

- A. Transfer heat and humidity from one air stream to the other with no carryover of the exhaust air into the supply air stream.
- B. Energy Recovery Media: Cleanable with low temperature steam, hot water or light detergent, without degrading the latent recovery.
- C. Effectiveness: Rated in accordance with ASHRAE Std 84 and AHRI 1060.
- D. Flame Spread Index: 25, maximum, when tested in accordance with ASTM E84, NFPA 255, and UL 723.
- E. Smoke Developed Index: 50, maximum, when tested in accordance with ASTM E84, NFPA 255, and UL 723.
- F. Energy Recovery Media Facing:
  - 1. Conform to NFPA 90A.
- G. Desiccant:
  - 1. Type: 3A.
  - 2. Performance:
    - a. Desiccant: Non-dissolving, permanent, and resistant to damage from compressed air, low temperature steam, hot water or by vacuum cleaning.

## 2.06 FILTERS

- A. Efficiency: 13 MERV.
- B. Fresh Air Stream: MERV 13 filters constructed to meet ASHRAE Std 52.2.
- C. Exhaust Air Stream: MERV 8 filters constructed to meet ASHRAE Std 52.2.
- D. Mount 1/2 inches thick permanent aluminum washable type filter in the outside air hood and in the return plenum air.
- E. Provide spare set of filters.

## 2.07 DAMPERS

- A. Motorized Dampers: Provide motorized dampers at outside air inlet and exhaust air outlet.
  - 1. Type: Motorized two position low-leak.
  - 2. Motorized Damper: Roll-formed structural hat channels, reinforced at the corners,
  - 3. Formed from single piece of minimum 16 gage, 0.0598 inch galvanized steel.
  - 4. Blades: Insulated, multiple blade damper.
  - 5. Blade Edge Seals: PVC coated polyester fabric suitable for minus 25 degrees F to 180 degrees F.
  - 6. Jamb Seals: Flexible stainless, compression type to prevent leakage between end of the blade and the damper frame.
  - 7. Bearings: Corrosion resistant, molded synthetic sleeve type turning in extruded hole in damper frame.
  - 8. Conceal linkage out of air stream, within damper frame to reduce pressure drop and noise and lessen need for maintenance.

## 2.08 ROOF CURBS

A. Curbs: Provide full perimeter, 20" roof curb fabricated from 10 gage aluminized steel.

- B. Isolation Rails: 12 gage aluminized steel angles top and bottom, connected with flexible, outdoor rated membrane and factory-installed vibration isolation springs.
- C. Gaskets: Provide closed cell PVC foam.
  - 1. Install between top flange of isolation rail and bottom of energy recovery unit.
  - 2. Install on top of curb.

## 2.09 POWER AND CONTROLS

- A. Motor Control Panels: UL listed.
- B. Include necessary motor starters, VFDs, fuses, transformers and overload protection according to NFPA 70.
- C. Provide single-point field connection to power supply.
- D. Provide non fused main disconnect integral to control panel.
- E. Install wiring in accordance with NFPA 70.
- F. Wiring: Enclosed in flexible, liquid tight steel conduit.

#### 2.10 SERVICE ACCESSORIES

- A. Internal Service Lights: Provide vapor tight light with protective cage and minimum 40 watt bulb.
- B. Electrical Receptacle:
  - 1. Provide duplex, ground fault interrupter type receptacle.
  - 2. Provide re-settable circuit breaker in control panel.
- C. Switch: 2 type.
  - 1. Two Position Type: Service and Operate.
- D. Electrical Components: Factory wired for single point power connection.
  - 1. Protect all integral wires and connections.
  - 2. Electrical Components: UL Listed.

## PART 3 EXECUTION

#### 3.01 EXAMINATION

A. Verify that structure is ready for installation of unit, that openings in deck for ductwork, if required, are correctly sized and located, and that mechanical and electrical utilities supplying unit are of correct capacities and are accessible.

#### 3.02 INSTALLATION

- A. Provide openings for suitable ductwork connection.
- B. Provide flexible duct connectors at ducted openings.
- C. Outdoor Installations:
  - 1. Provide drip edge around roof perimeter.
  - 2. Do not locate roof panel joints above doors.

## 3.03 SYSTEM STARTUP

A. Provide services of manufacturer's authorized representative to provide start up of unit.

## 3.04 CLEANING

A. Clean filters, air plenums, interior and exposed-to-view surfaces prior to Substantial Completion.

END OF SECTION

THIS PAGE MILINION MILLING MAIL
# SECTION 23 81 01 TERMINAL HEAT TRANSFER UNITS

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Baseboard radiation.
- B. Unit heaters.
- C. Electric heaters.
- D. Electric duct heaters.

#### 1.02 RELATED REQUIREMENTS

- A. Section 23 05 13 Motor Requirements for HVAC and Plumbing Equip.
- B. Section 23 21 13 Hydronic Piping.
- C. Section 23 21 14 Hydronic Specialties.
- D. Section 23 09 93 Sequence of Operations for HVAC Controls.
- E. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections. Installation of room thermostats. Electrical supply to units.

#### 1.03 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide typical catalog of information including arrangements.
- C. Shop Drawings:
  - 1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
  - 2. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
  - 3. Indicate mechanical and electrical service locations and requirements.,
- D. Manufacturer's Instructions: Indicate installation instructions and recommendations.
- E. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.
- F. Operation and Maintenance Data: Include manufacturers descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
- G. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Caesar Rodney School District's name and registered with manufacturer.

#### 1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum 5 years documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

## 1.05 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturers warranty for all motors.
- C. Provide one year parts and labor warranty for enitre unit, from substitute and completion.

## 1.06 EXTRA MATERIALS

A. See Section 01 6000 - Product Requirements, for additional provisions.

B. Provide three (3) sets of filters, with a final change immediately prior to occupancy.

## PART 2 PRODUCTS

## 2.01 ELECTRIC BASEBOARD

- A. Manufacturers:
  - 1. Marley: www.marleymep.com
  - 2. QMark: www.sylvane.com
  - 3. Brasch: www.braschmfg.com
  - 4. Trane: www.trane.com
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
- B. Assembly: UL listed and labelled with terminal box and cover, and built-in controls.
- C. Heating Elements: Enclosed copper tube, aluminum finned element of coiled nickel-chrome resistance wire centered in tubes and embedded in refractory material.
- D. Enclosure: Minimum 0.030 inch steel with 7 inch high back and top of one piece; front panel, end panel, end caps, corners, and joiner pieces to snap together, and front panel easily removable. Provide full length damper.
- E. Control: Electronic control system with baseboard mounted power module and wall-mounted thermostat.

# 2.02 ELECTRIC UNIT HEATERS

- A. Manufacturers:
  - 1. Marley: www.marleymep.com
  - 2. QMark: www.sylvane.com
  - 3. Brasch: www.braschmfg.com
  - 4. Trane: www.trane.com
- B. Assembly: UL listed and labelled assembly with terminal box and cover, and built-in controls.
- C. Heating Elements: Enclosed copper tube, aluminum finned element of coiled nickel-chrome resistance wire centered in tubes and embedded in refractory material or exposed helical coil of pickel chrome resistance wire refractory ceramic support bushings.
- D. Cabinet: 0.0478 inch steel with easily removed front panel with integral air outlet and inlet grilles.
- E. Element Hangers: Quiet operating, ball bearing cradle type providing unrestricted longitudinal movement, on enclosure brackets.
- F. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard.
- G. Motor: Permanently lubricated, sleeve bearings for horizontal models, ball bearings for vertical models.
- H. Control: Separate fan speed switch and wall-mounted thermostat heat selector switch, factory wired, with switches built-in behind cover. Provide thermal overload.

## 2.03 ELECTRIC DUCT-MOUNTED HEATERS

- A. Manufacturers:
  - 1. Marley: www.marleymep.com
  - 2. QMark: www.sylvane.com
  - 3. Brasch: www.braschmfg.com
- B. Assembly: UL listed and labelled assembly with terminal box and cover, and lockable handle with integral electrical disconnect.

- C. Heating Elements: Enclosed copper tube, aluminum finned element of coiled nickel-chrome resistance wire centered in tubes and embedded in refractory material or exposed helical coil of pickel chrome resistance wire refractory ceramic support bushings.
- D. Cabinet: 0.0478 inch steel with easily removed front panel with integral air outlet and inlet grilles.
- E. Element Hangers: Quiet operating, ball bearing cradle type providing unrestricted longitudinal movement, on enclosure brackets.
- F. Control: SCR Control with 0-10V input signal. See sequence of operations for BAS control requirements.

## PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install equipment exposed to finished areas after walls and ceiling are finished and painted. Do not damage equipment or finishes.
- C. Protection: Provide finished cabinet units with protective covers during balance of construction.
- D. Baseboard Radiation: Locate on outside walls and run cover continuously wall-to-wall unless otherwise indicated. Center elements under windows. Install end caps where units butt against walls.
- E. Unit Heaters: Hang from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.
- F. Install electric heating equipment including devices furnished by manufacturer but not factory-mounted. Furnish copy of manufacturer's wiring diagram submittal. Install electrical wiring in accordance with manufacturer's submittals and Section 26 27 17.

## 3.02 CLEANING

- A. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.
- B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
- C. Install new filters.

## END OF SECTION

THIS PAGE MILINION MILLING MAIL

# SECTION 23 81 27 SMALL SPLIT-SYSTEM HEATING AND COOLING

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Air cooled condensing units.
- B. Indoor ductless fan & coil units.
- C. Controls.

#### 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Mounting pad for outdoor unit.
- B. Section 22 10 05 Plumbing Piping: Indoor coil condensate drain.
- C. Section 23 09 13 Instrumentation and Control Devices for HVAC: Thermostats, humidistats, time clocks.
- D. Section 23 09 23 Direct Digital Controls Systems for HVAC.
- E. Section 23 09 93 Sequence of Operations for HVAC.
- F. Section 26 27 17 Equipment Wiring: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

#### 1.03 REFERENCE STANDARDS

- A. AHRI 270 Sound Performance Rating of Outdoor Unitary Equipment.
- B. AHRI 520 Performance Rating of Positive Displacement Condensing Units.
- C. AHRI 610 (I-P) Performance Rating Of Central System Humidifiers for Residential Applications.
- D. ASHRAE Std 15 Safety Standard for Refrigeration Systems.
- E. ASHRAE Std 23.1 Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units.
- F. ASHRAE Std 52.1 Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
- G. ASHRAE Std 90.1 I-P Energy Standard for Buildings Except Low-Rise Residential Buildings.
- H. ASHRAE Std 90.2 Energy-Efficient Design of New Low-Rise Residential Buildings.
- I. ASHRAE Std 103 Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers.
- J. NEMA MG 1 Motors and Generators.
- K. NFPA 31 Standard for the Installation of Oil Burning Equipment.
- L. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems.
- M. NFPA 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- N. NFPA 211 Guide for Smoke and Heat Venting.
- O. UL 207 Standard for Refrigerant-Containing Components and Accessories, Nonelectrical.

#### 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

- C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- D. Design Data: Indicate refrigerant pipe sizing.
- E. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- F. Project Record Documents: Record actual locations of components and connections.
- G. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- H. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Caesar Rodney School District s name and registered with manufacturer.

## 1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum 10 years of documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years of documented experience and approved by manufacturer.

## 1.06 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturers warranty for heat exchangers, condensing units, and compressors.

## 1.07 EXTRA MATERIALS

- A. See Section 01 6000 Project Requirements, for additional provisions.
- B. Provide two filters for each indoor unit.

## PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Mitsubishi:
- B. LG:
- C. Daikin
- D. Samsung
- E. Substitutions: See Section 01 60 00 Product Requirements.

## 2.02 SYSTEM DESIGN

- A. Split-System Heating and Cooling Units: Self-contained, packaged, matched
  - factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
    - 1. Heating and Cooling: Air-source electric heat pump located in outdoor unit with evaporator
    - 2. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B. Performance Requirements: See Drawings for additional requirements.
  - 1. Efficiency: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than requirements of ASHRAE Std 90.1; seasonal efficiency to ASHRAE Std 103.

## 2.03 INDOOR UNITS FOR DUCTLESS SYSTEMS

A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.

- B. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
  - 1. Construction and Ratings: In accordance with AHRI 210/240 and UL listed.
  - 2. Manufacturer: System manufacturer.

#### 2.04 OUTDOOR UNITS

- A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
  - 1. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
  - 2. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23 and UL listed.
- B. Compressor: As scheduled ARI 520; hermetic, single or two speed 1800 and 3600 rpm, resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.
- C. Air Cooled Condenser: ARI 520; Aluminum fin and copper tube coil, with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
- D. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gage ports, thermometer well (in liquid line).
  - 1. Provide thermostatic expansion valves.
  - 2. Provide heat pump reversing valves.
- E. Operating Controls:
  - 1. Control by room thermostat to maintain room temperature setting.
  - 2. Low Ambient Kit: Provide refrigerant pressure switch to cycle condenser fan on when condenser refrigerant pressure is above 285 psig and off when pressure drops below 140 psig for operation to 0 degrees F.
- F. Mounting Pad: Minimum square; minimum of two located under cabinet feet.

#### 2.05 ACCESSORY EQUIPMENT

A. Controls: Provide BAS interface. See Sequence of Operations.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available and in correct location.
- C. Verify that proper fuel supply is available for connection.
- D. Verify that water supply is available for humidifier.

#### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.
- B. Mount wall-mounted units at 7'-0" above finished floor.
- C. Provide with condensate removal pump.
- D. Install in accordance with NFPA 90A and NFPA 90B.
- E. Provide vent connections in accordance with NFPA 211.

F. Install refrigeration systems in accordance with ASHRAE Std 15. END OF SECTION

#### SECTION 23 81 29

#### VARIABLE REFRIGERANT VOLUME (VRV, VRF) HVAC SYSTEM

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Variable refrigerant volume HVAC system includes:
  - 1. Outdoor/Condensing unit(s).
  - 2. Indoor/Evaporator units.
  - 3. Branch selector units.
  - 4. Refrigerant piping.
  - 5. Control panels.
  - 6. Control wiring.

## 1.02 RELATED REQUIREMENTS

- A. Section 01 23 00 Alternates: List of alternates relevant to this section.
- B. Section 01 79 00 Demonstration and Training.
- C. Section 22 10 05 Plumbing Piping: Condensate drain piping.
- D. Section 22 30 00 Plumbing Equipment: Cooling condensate removal pumps.
- E. Section 23 08 00 Commissioning of HVAC.
- F. Section 23 23 00 Refrigerant Piping and Specialties: Additional requirements for refrigerant piping system.
- G. Section 26 27 17 Equipment Wiring: Power connections to equipment.
  1. Provide separate power connections for each unit of equipment.
- H. Section 23 09 23 and 23 09 93: Building automation system providing centralized control of this system.
- I. Section 01 91 00 Commissioning
- J. Section 01 91 10 Functional Testing Procedures
- K. Section 23 08 00 Mechanical Systems Commissioning
- L. Section 23 08 10 Control Systems Commissioning

#### 1.03 REFERENCE STANDARDS

- A. AHRI 210/240 Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- B. ASHRAE (FUND) ASHRAE Handbook Fundamentals.
- C. ASHRAE Std 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings.
- D. NFPA 70 National Electrical Code.
- E. UL 1995 Heating and Cooling Equipment.

#### 1.04 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

#### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Pre-Bid Submittals: For proposed substitute systems/products, as defined in PART 2, and alternate systems/products, as defined above, proposer shall submit all data described in this article, under the terms given for substitutions stated in PART 2.

- C. Design Data:
  - 1. Provide design calculations showing that system will achieve performance specified.
  - 2. Provide design data required by ASHRAE 90.1.
- D. Product Data: Submit manufacturer's standard data sheets showing the following for each item of equipment, marked to correlate to equipment item markings shown in the contract documents:
  - 1. Outdoor/Central Units:
    - a. Refrigerant Type and Size of Charge.
    - b. Cooling Capacity: Btu/h.
    - c. Heating Capacity: Btu/h.
    - d. Cooling Input Power: Btu/h.
    - e. Heating Input Power: Btu/h.
    - f. Operating Temperature Range, Cooling and Heating.
    - g. Air Flow: Cubic feet per minute.
    - h. Fan Curves.
    - i. External Static Pressure (ESP): Inches WG.
    - j. Sound Pressure Level: dB(A).
    - k. Electrical Data:
      - 1) Maximum Circuit Amps (MCA).
      - 2) Maximum Fuse Amps (MFA).
      - 3) Maximum Starting Current (MSC).
      - 4) Full Load Amps (FLA).
      - 5) Total Over Current Amps (TOCA).
      - 6) Fan Motor: HP.
    - I. Weight and Dimensions.
    - m. Maximum number of indoor units that can be served.
    - n. Maximum refrigerant piping run from outdoor/condenser unit to indoor/evaporator unit.
    - o. Maximum height difference between outdoor/condenser unit to indoor/evaporator unit, both above and below.
    - p. Control Options.
  - 2. Indoor/Evaporator Units:
    - a. Cooling Capacity: Btu/h.
    - b. Heating Capacity: Btu/h.
    - c. Cooling Input Power: Btu/h.
    - d. Heating Input Power: Btu/h.
    - e. Air Flow: Cubic feet per minute.
    - f. Fan Curves.
    - g. External Static Pressure (ESP): Inches WG.
    - h. Sound Pressure level: dB(A).
    - i. Electrical Data:
      - 1) Maximum Circuit Amps (MCA).
      - 2) Maximum Fuse Amps (MFA).
      - 3) Maximum Starting Current (MSC).
      - 4) Full Load Amps (FLA).
      - 5) Total Over Current Amps (TOCA).
      - 6) Fan Motor: HP.
    - j. Maximum Lift of Built-in Condensate Pump.
    - k. Weight and Dimensions.
    - . Control Options.
  - 3. Control Panels: Complete description of options, control points, zones/groups.

- E. Shop Drawings: Installation drawings custom-made for this project; include as-designed HVAC layouts, locations of equipment items, refrigerant piping sizes and locations, condensate piping sizes and locations, remote sensing devices, control components, electrical connections, control wiring connections. Include:
  - 1. Detailed piping diagrams, with branch balancing devices.
  - 2. Condensate piping routing, size, and pump connections.
  - 3. Detailed power wiring diagrams.
  - 4. Detailed control wiring diagrams.
  - 5. Locations of required access through fixed construction.
  - 6. Drawings required by manufacturer.
  - 7. In addition to paper copies, submit shop drawings as CAD files in DXF format.
  - 8. Architect will furnish CAD files for use in preparing shop drawings.
- F. Design Data:
  - 1. Provide design calculations showing that system will achieve performance specified.
  - 2. Provide design data required by ASHRAE Std 90.1.
- G. Specimen Warranty: Copy of manufacturer's warranties.
- H. Shop Drawings: Installation drawings custom-made for this project; include as-designed HVAC layouts, locations of equipment items, refrigerant piping sizes and locations, condensate piping sizes and locations, remote sensing devices, control components, electrical connections, control wiring connections. Include:
  - 1. Detailed piping diagrams, with branch balancing devices.
  - 2. Condensate piping routing, size, and pump connections.
  - 3. Detailed power wiring diagrams.
  - 4. Detailed control wiring diagrams.
  - 5. Locations of required access through fixed construction.
  - 6. Drawings required by manufacturer.
- I. Operating and Maintenance Data:
  - 1. Manufacturer's complete standard instructions for each unit of equipment and control panel.
  - 2. Custom-prepared system operation, troubleshooting, and maintenance instructions and recommendations.
  - 3. Identification of replaceable parts and local source of supply.
- J. Project Record Documents: Record the following:
  - 1. As-installed routing of refrigerant piping and condensate piping.
  - 2. Locations of access panels.
  - 3. Locations of control panels.
- K. Warranty: Executed warranty, made out in Owner's name.

## 1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
  - 1. Company that has been manufacturing variable refrigerant volume heat pump equipment for at least 5 years.
  - 2. Company that provides system design software to installers.
- B. Installer Qualifications: Trained and approved by manufacturer of equipment.

## 1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle equipment and refrigerant piping according to manufacturer's recommendations.

#### 1.08 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Compressors: Provide manufacturer's warranty for six (6) years from date of installation. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced by the manufacturer. All warranty service work shall be performed by a factory trained service professional.

## PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Basis of Design: The system design shown in the contract documents is based on equipment and system designed by Daikin.
- B. Additional acceptable manufacturers:
  - 1. Mitsubishi: www.mistubishi-electric.co.nz
  - 2. LG Industries: www.lg-vrf.com
  - 3. Samsung: www.www.samsungaccentre.com
- C. For systems proposed by other manufacturers other than the basis of design, Daikin, <u>all</u> required modifications to the design and installation shall be the responsibility of the contractor and supplier for both costs and coordination with all other contractors and designers. These changes include, but are not limited to:
  - 1. Changes in refrigerant piping sizes, legnhts, and locations.
  - 2. Changes in branch selector quantities, locations, and accessibility.
  - 3. Changes in electrical requirements, including all power wiring, terminations, breakers, disconnects, and control wiring.
  - 4. Changes in heat-pump unit locations and quantities.
  - 5. Changes in structural supports, vibration isolation, and hangers.
  - 6. Changes to the drawings to reflect the new system parameters.

#### 2.02 HVAC SYSTEM DESIGN

- A. System Operation: Heating and cooling, simultaneously.
  - 1. Zoning: Provide capability for temperature control for each individual indoor/evaporator unit independently of all other units.
  - 2. Zoning: Provide heating/cooling selection for each individual indoor/evaporator unit independently of all other units.
  - 3. Provide a complete functional system that achieves the specified performance based on the specified design conditions and that is designed and constructed according to the equipment manufacturer's requirements.
  - 4. Conditioned spaces are shown on the drawings.
  - 5. Branch selector unit locations are shown on the drawings for reference only. Final design locations shall be corrdinated in the field to ensure optimized line lengths and maintanence access.
  - 6. Required equipment unit capacities are shown on the drawings.
  - 7. Refrigerant piping sizes shown on the drawings are for general reference only. Final line sizing shall be the responsibility of the successful contractor and manufacturer.
  - 8. Connect equipment to condensate piping; condensate piping is shown on the drawings.
- B. Outside Air Design Conditions:
  - 1. Summer Outside Air Design Temperature: 0.4 percent cooling design condition listed in ASHRAE Fundamentals Handbook.
  - 2. Winter Outside Air Design Temperature: 99.6 percent heating design condition listed in ASHRAE Fundamentals Handbook ASHRAE (FUND).

- C. Operating Temperature Ranges:
  - 1. Simultaneous Heating and Cooling Operating Range: minus 4 degrees F to 60 degrees F dry bulb.
  - 2. Cooling Mode Operating Range: minus 4 degrees F to 110 degrees F dry bulb.
  - 3. Heating Mode Operating Range: 0 degrees F to 77 degrees F dry bulb; minus 4 degrees F to 60 degrees F wet bulb; without low ambient controls or auxiliary heat source.
- D. Refrigerant Piping Lengths: Provide equipment capable of serving system with following piping lengths without any oil traps:
  - 1. Minimum Piping Length from Outdoor/Central Unit(s) to Furthest Terminal Unit: 540 feet, actual; 620 feet, equivalent.
  - 2. Total Combined Liquid Line Length: 3280 feet, minimum.
  - 3. Minimum Piping Length Between Indoor Units: 49 feet.
- E. Controls: Provide the following control interfaces:
  - 1. For Each Indoor/Evaporator Unit: One wired "local" controller, with temperature sensor; locate where indicated.
    - a. Where two or more units are used to condition the same space, provide a splitter or twinning kit to allow for multiple unit control from a single controller.
    - b. Unit controller is to be mounted above the ceiling at the unit and a remote temperature sensor is to be installed in the space.
  - 2. One central remote control panel for entire system; locate where indicated.
  - 3. BACNet gateways sufficient to connect all units to building automation system by others; include wiring to gateways. Unit shall be BTL certified.
  - 4. Building automation system by HVAC system manufacturer ; provide one user stations located where directed.
- F. Local Controllers: Local controllers are to be installed above ceiling at unit, and BAS contractor is to provide wall-mounted flat-plate temperature sensor with no display or adjustment. For units installed in inaccessible ceilings, install controller at nearest accessible location and provide ceiling tack.

#### 2.03 EQUIPMENT

- A. All Units: Factory assembled, wired, and piped and factory tested for function and safety.
  - 1. Refrigerant: R-410A.
  - 2. Performance Certification: AHRI Certified; www.ahrinet.org.
  - 3. Safety Certification: Tested to UL 1995 by UL or Intertek-ETL and bearing the certification label.
  - 4. Provide outdoor/condensing units capable of serving indoor unit capacity up to 200 percent of the capacity of the outdoor/condensing unit.
  - 5. Provide units capable of serving the zones indicated.
  - 6. Thermal Performance: Provide heating and cooling capacity as indicated, based on the following nominal operating conditions:
  - Energy Efficiency: Report EER and COP based on tests conducted at "full load" in accordance with AHRI 210/240 or alternate test method approved by U.S. Department of Energy.
- B. Electrical Characteristics:
  - 1. See drawings.
- C. System Controls:
  - 1. Include self diagnostic, auto-check functions to detect malfunctions and display the type and location.

- D. Unit Controls: As required to perform input functions necessary to operate system; provided by manufacturer of units.
  - 1. Provide interfaces to remote control and building automation systems in BACNET native format.
- E. Wiring:
  - 1. Control Wiring: 18 AWG, 2-conductor, non-shielded, non-polarized, stranded cable.
  - 2. Control Wiring Configuration: Daisy chain.
  - 3. All control wiring for the VRF system in it's entirety is the responsibility of the installing contractor, including, but not limited to: Wiring between the condensing unit(s) and system controller, wiring between the branch selector boxes and system controller, wiring from the terminal units to the system controllers, wiring from the thermostats to the terminal units. The BAS contractor shall only be required to provide communications wiring to the BACnet interface from the nearest BAS controller.
- F. Refrigerant Piping:
  - 1. Provide three-pipe refrigerant system, including high/low pressure dedicated hot gas, liquid and suction lines; two-pipe systems utilizing lower temperature mixed liquid/gas refrigerant to perform heat recovery are not permitted due to reduced heating capabilities.
  - 2. Refrigerant Flow Balancing: Provide refrigerant piping joints and headers specifically designed to ensure proper refrigerant balance and flow for optimum system capacity and performance.
  - 3. Insulate each refrigerant line individually between the condensing and indoor units.

#### 2.04 OUTDOOR/CONDENSING UNITS

- A. Outdoor/Condensing Units: Air-cooled DX refrigeration units, designed specifically for use with indoor/evaporator units; factory assembled and wired with all necessary electronic and refrigerant controls; modular design for ganging multiple units.
  - 1. Refrigeration Circuit: Scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
  - 2. Refrigerant: Factory charged.
  - 3. Variable Volume Control: Modulate compressor capacity automatically to maintain constant suction and condensing pressures while varying refrigerant volume to suit heating/cooling loads.
  - 4. Capable of being installed with wiring and piping to the left, right, rear or bottom.
  - 5. Capable of heating operation at low end of operating range as specified, without additional low ambient controls or auxiliary heat source; during heating operation, reverse cycle (cooling mode) oil return or defrost is not permitted, due to potential reduction in space temperature.
  - 6. Sound Pressure Level: As specified, measured at 3 feet from front of unit; provide night setback sound control as a standard feature; three selectable sound level steps of 55 dB, 50 dB, and 45 dB, maximum.
  - 7. Power Failure Mode: Automatically restart operation after power failure without loss of programmed settings.
  - 8. Safety Devices: High pressure sensor and switch, low pressure sensor/switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
  - 9. Provide refrigerant sub-cooling to ensure the liquid refrigerant does not flash when supplying to us indoor units.
  - 10. Oil Recovery Cycle: Automatic, occurring 2 hours after start of operation and then every 8 hours of operation; maintain continuous heating during oil return operation.

- 11. Controls: Provide contacts for electrical demand shedding.
- B. Unit Cabinet: Weatherproof and corrosion resistant; rust-proofed mild steel panels coated with baked enamel finish.
  - 1. Designed to allow side-by-side installation with minimum spacing.
- C. Fans: One or more direct-drive propeller type, vertical discharge, with multiple speed operation via DC (digitally commutating) inverter.
  - 1. Provide minimum of 2 fans for each condensing unit.
  - 2. External Static Pressure: Factory set at 0.12 in WG, minimum.
  - 3. Indoor Mounted Air-Cooled Units: External static pressure field set at 0.32 in WG, minimum; provide for mounting of field-installed ducts.
  - 4. Fan Airflow: As indicated for specific equipment.
  - 5. Fan Motors: Factory installed; permanently lubricated bearings; inherent protection; fan guard; output as indicated for specific equipment.
- D. Condenser Coils: Copper tubes expanded into aluminum fins to form mechanical bond; waffle louver fin and rifled bore tube design to ensure high efficiency performance.
- E. Compressors: Scroll type, hermetically sealed, variable speed inverter-driven and fixed speed in combination to suit total capacity; minimum of one variable speed, inverter driven compressor per condenser unit; minimum of two compressors per condenser unit; capable of controlling capacity within range of 6 percent to 100 percent of total capacity.
  - 1. Variable Speed Control: Capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure; high/low pressures calculated by samplings of evaporator and condenser temperatures every 20 seconds, with compressor capacity adjusted to eliminate deviation from target value by changing inverter frequency or on/off setting of fixed speed compressors.
  - 2. Multiple Condenser Modules: Balance total operation hours of compressors by means of duty cycling function, providing for sequential starting of each module at each start/stop cycle, completion of oil return, and completion of defrost, or every 8 hours. Provide twinning kits where required.
  - 3. Failure Mode: In the event of compressor failure, operate remaining compressor(s) at proportionally reduced capacity; provide microprocessor and associated controls specifically designed to address this condition.
  - 4. Inverter Driven Compressors: PVM inverter driven, highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "G2-type" with maximum speed of 7,980 rpm.
  - 5. Rotors: Incorporating neodymium magnets for higher torque and efficiency; at complete stop of compressor, position rotor into optimum position for low torque start.
  - 6. Provide each compressor with crankcase heater, high pressure safety switch, and internal thermal overload protector.
  - 7. Provide oil separators and intelligent oil management system.
  - 8. Provide spring mounted vibration isolators.

## 2.05 BRANCH SELECTOR UNITS

- A. Branch Selector Units: Concealed boxes designed specifically for this type of system to control heating/cooling mode selection of downstream units; consisting of electronic expansion valves, subcooling heat exchanger, refrigerant control piping and electronics to facilitate communications between unit and main processor and between branch unit and indoor/evaporator units.
  - 1. Control direction of refrigerant flow using electronic expansion valves; use of solenoid valves for changeover and pressure equalization is not permitted due to refrigerant noise; use of multi-port branch selector boxes is not permitted unless spare ports are provided for redundancy.

- 2. Provide one electronic expansion valve for each downstream unit served, except multiple indoor/evaporator units may be connected, provided balancing joints are used in downstream piping and total capacity is within capacity range of the branch selector.
- 3. When branch unit is simultaneously heating and cooling, energize subcooling heat exchanger.
- 4. Casing: Galvanized steel sheet; with flame and heat resistant foamed polyethylene sound and thermal insulation.
- 5. Refrigerant Connections: Braze type.
- 6. Condensate Drainage: Provide condensate drain tap where required.

## 2.06 INDOOR/EVAPORATOR UNITS

- A. All Indoor/Evaporator Units: Factory assembled and tested DX fan-coil units, with electronic proportional expansion valve, control circuit board, factory wiring and piping, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
  - 1. Refrigerant: Refrigerant circuits factory-charged with dehydrated air, for field charging.
  - 2. Temperature Control Mechanism: Return air thermistor and computerized Proportional-Integral-Derivative (PID) control of superheat.
  - 3. Dehumidification Function: On command.
  - 4. Coils: Direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond; waffle louver fin and high heat exchange, rifled bore tube design; factory tested.
    - a. Provide thermistor on liquid and gas lines.
  - 5. Fans: Direct-drive, with statically and dynamically balanced impellers; high and low speeds unless otherwise indicated; motor thermally protected.
  - 6. Return Air Filter: High efficiency, MERV 13
    - a. Where high efficiency filters are indicated, provide air filter rack.
  - 7. Condensate Drainage: Built-in condensate drain pan with PVC drain connection.
    - a. Units With Built-In Condensate Pumps: Provide condensate safety shutoff and alarm.
    - b. Units Without Built-In Condensate Pump: Provide built-in condensate float switch and wiring connections.
  - 8. Cabinet Insulation: Sound absorbing foamed polystyrene and polyethylene insulation.
- B. Recessed Ceiling Units: Four-way airflow cassette with central return air grille, for installation in a fixed ceiling.
  - 1. Cabinet Height: Maximum of 10 inches above face of ceiling.
  - 2. Exposed Housing: White, impact resistant, with washable decoration panel.
  - 3. Supply Airflow Adjustment:
    - a. Via motorized louvers which can be horizontally and vertically adjusted from 0 to 90 degrees.
    - b. Field-modifiable to 3-way and 2-way airflow.
    - c. Three auto-swing positions, including standard, draft prevention and ceiling stain prevention.
  - 4. Return Air Filter: High efficiency, MERV 13.
  - 5. Minimum Capacity: As indicated on the drawings.
  - 6. Sound Pressure Range: Between 28 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
  - 7. Fan: Direct-drive turbo type, with motor output range of 0.06 to 0.12 HP.
  - 8. Condensate Pump: Built-in, with lift of 24 inches, minimum.
  - 9. Provide side-mounted fresh air intake duct connection.
- C. Concealed-In-Ceiling Units: Ducted horizontal discharge and return; galvanized steel cabinet.
  - 1. Return Air Filter: MERV 13.
  - 2. Sound Pressure: Measured at low speed at 5 feet below unit.

- 3. Provide external static pressure switch adjustable for high efficiency filter operation
- 4. Condensate Pump: Built-in, with lift of 24 inches, minimum.
- 5. Switch box accessible from side or bottom.
- D. Wall Surface-Mounted Units: Finished white casing, with removable front grille; foamed polystyrene and polyethylene sound insulation; wall mounting plate; polystyrene condensate drain pan.
  - 1. Airflow Control: Auto-swing louver that closes automatically when unit stops; five (5) steps of discharge angle, set using remote controller; upon restart, discharge angle defaulting to same angle as previous operation.
  - 2. Sound Pressure Range: Measured at low speed at 3.3 feet below and away from unit.
  - 3. Condensate Pump: Provide condensate removal pump.
  - 4. Condensate Drain Connection: Side (end), not concealed in wall.
  - 5. Fan: Direct-drive cross-flow type.

#### PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify that required electrical services have been installed and are in the proper locations prior to starting installation.
- B. Each indoor unit, outdoor unit, and branch selector unit is to be installed with dedicated circuit, including dedicated breaker and feeder.
- C. Verify that condensate piping has been installed and is in the proper location prior to starting installation.
- D. Notify StudioJAED if conditions for installation are unsatisfactory.

#### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install refrigerant piping in accordance with equipment manufacturer's instructions.
- C. Perform wiring in accordance with NFPA 70, National Electric Code (NEC).
- D. Coordinate with installers of systems and equipment connecting to this system.

#### 3.03 FIELD QUALITY CONTROL

A. Provide manufacturer's field representative to inspect installation prior to startup.

#### 3.04 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform system startup.
- B. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.
- C. Adjust equipment for proper operation within manufacturer's published tolerances.

#### 3.05 CLEANING

A. Clean exposed components of dirt, finger marks, and other disfigurements.

#### 3.06 CLOSEOUT ACTIVITIES

- A. Demonstrate proper operation of equipment to Caesar Rodney School District's designated representative.
- B. Demonstration: Demonstrate operation of system to Caesar Rodney School District's personnel.
  - 1. Use operation and maintenance data as reference during demonstration.
  - 2. Briefly describe function, operation, and maintenance of each component.

- C. Training: Train Caesar Rodney School District's personnel on operation and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Instructor: Manufacturer's training personnel.
  - 4. Location: At project site.

## 3.07 PROTECTION

- A. Protect installed components from subsequent construction operations.
- B. Replace exposed components broken or otherwise damaged beyond repair.

## 3.08 MAINTENANCE

A. See Section 01 70 00 - Execution Requirements, for additional requirements relating to maintenance service.

## END OF SECTION

# SECTION 26 05 01 MINOR ELECTRICAL DEMOLITION

#### PART 1 GENERAL

#### **1.01 SECTION INCLUDES**

A. Electrical demolition.

## 1.02 RELATED REQUIREMENTS

A. Section 01 70 00 - Execution and Closeout Requirements: Additional requirements for alterations work.

#### PART 2 PRODUCTS

## 2.01 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual sections.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify field measurements and circuiting arrangements are as shown on Drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation .
- D. Report discrepancies to Caesar Rodney School District before disturbing existing installation.
- E. Report discrepancies to StudioJAED before disturbing existing installation.
- F. Beginning of demolition means installer accepts existing conditions.

## 3.02 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
- B. Coordinate utility service outages with utility company.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
  - 1. Obtain permission from Caesar Rodney School District at least 24 hours before partially or completely disabling system.
  - 2. Make temporary connections to maintain service in areas adjacent to work area.
- E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Minimize outage duration.
  - 1. Notify Caesar Rodney School District before partially or completely disabling system.
  - 2. Notify local fire service.
  - 3. Make notifications at least 24 hours in advance.
  - 4. Make temporary connections to maintain service in areas adjacent to work area.

#### 3.03 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Remove, relocate, and extend existing installations to accommodate new construction.
- B. Remove abandoned wiring to source of supply.
- C. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.

- D. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.
- E. Disconnect and remove abandoned panelboards and distribution equipment.
- F. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- G. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- H. Repair adjacent construction and finishes damaged during demolition and extension work.
- I. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
- J. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

#### 3.04 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment that remain or that are to be reused.
- B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.
- C. Luminaires: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts and broken electrical parts.
- D. Any lighting or ceiling-mounted devices removed during construction must be reinstalled.

## END OF SECTION

#### SECTION 26 05 19

#### LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

## PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Single conductor building wire.
- B. Underground feeder and branch-circuit cable.
- C. Service entrance cable.
- D. Armored cable.
- E. Metal-clad cable.
- F. Wiring connectors.
- G. Electrical tape.
- H. Heat shrink tubing.
- I. Oxide inhibiting compound.
- J. Wire pulling lubricant.
- K. Cable ties.

#### 1.02 RELATED REQUIREMENTS

- A. Section 07 84 00 Firestopping.
- B. Section 26 05 01 Minor Electrical Demolition: Disconnection, removal, and/or extension of existing electrical conductors and cables.
- C. Section 26 05 26 Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- D. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- E. Section 28 31 00 Fire Detection and Alarm: Fire alarm system conductors and cables.
- F. Section 31 23 16 Excavation.
- G. Section 31 23 16.13 Trenching: Excavating, bedding, and backfilling.
- H. Section 31 23 23 Fill: Bedding and backfilling.

#### 1.03 REFERENCE STANDARDS

- A. ASTM B3 Standard Specification for Soft or Annealed Copper Wire.
- B. ASTM B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. ASTM B33 Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
- D. ASTM B787/B787M Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation.
- E. ASTM D3005 Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- F. ASTM D4388 Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes.
- G. NECA 1 Standard for Good Workmanship in Electrical Construction.
- H. NECA 120 Standard for Installing Armored Cable (AC) and Metal-Clad Cable (MC).

- I. NECA 121 Standard for Installing Nonmetallic-Sheathed Cable (Type NM-B) and Underground Feeder and Branch-Circuit Cable (Type UF).
- J. NEMA WC 70 Nonshielded Power Cable 2000 V or Less for the Distribution of Electrical Energy.
- K. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- L. NFPA 70 National Electrical Code.
- M. UL 4 Armored Cable.
- N. UL 44 Thermoset-Insulated Wires and Cables.
- O. UL 83 Thermoplastic-Insulated Wires and Cables.
- P. UL 486A-486B Wire Connectors.
- Q. UL 486C Splicing Wire Connectors.
- R. UL 486D Sealed Wire Connector Systems.
- S. UL 493 Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables.
- T. UL 510 Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
- U. UL 1569 Metal-Clad Cables.

## 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
  - 2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
  - 3. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.
- C. Sustainable Design Documentation: Submit manufacturer's product data on conductor and cable showing compliance with specified lead content requirements.
- D. Design Data: Indicate voltage drop and ampacity calculations for aluminum conductors substituted for copper conductors. Include proposed modifications to raceways, boxes, wiring gutters, enclosures, etc. to accommodate substituted conductors.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- F. Project Record Documents: Record actual installed circuiting arrangements. Record actual routing for underground circuits.

## 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

## 1.08 FIELD CONDITIONS

A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify StudioJAED and obtain direction before proceeding with work.

#### PART 2 PRODUCTS

## 2.01 CONDUCTOR AND CABLE APPLICATIONS

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.

#### 2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D. Comply with NEMA WC 70.
- E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G. Conductors for Grounding and Bonding: Also comply with Section 26 05 26.
- H. Conductors and Cables Installed Exposed in Spaces Used for Environmental Air (only where specifically permitted): Plenum rated, listed and labeled as suitable for use in return air plenums.
- I. Conductor Material:
  - 1. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B 787M unless otherwise indicated.
  - 2. Tinned Copper Conductors: Comply with ASTM B33.
- J. Minimum Conductor Size:
  - 1. Branch Circuits: 12 AWG.
    - a. Exceptions:
      - 1) 20 A, 120 V circuits longer than 75 feet: 10 AWG, for voltage drop.
      - 2) 20 A, 120 V circuits longer than 150 feet: 8 AWG, for voltage drop.
      - 3) 20 A, 277 V circuits longer than 150 feet: 10 AWG, for voltage drop.
  - 2. Control Circuits: 14 AWG.
- K. Conductor Color Coding:

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- 1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
- 2. Color Coding Method: Integrally colored insulation.
  - a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
- 3. Color Code:
  - a. 480Y/277 V, 3 Phase, 4 Wire System:
    - 1) Phase A: Brown.
    - 2) Phase B: Orange.
    - 3) Phase C: Yellow.
    - 4) Neutral/Grounded: Gray.
  - b. 208Y/120 V, 3 Phase, 4 Wire System:
    - 1) Phase A: Black.
    - 2) Phase B: Red.
    - 3) Phase C: Blue.
    - 4) Neutral/Grounded: White.
  - c. Equipment Ground, All Systems: Green.
  - d. Isolated Ground, All Systems: Green with yellow stripe.
  - e. Travelers for 3-Way and 4-Way Switching: Pink.
  - f. For control circuits, comply with manufacturer's recommended color code.

## 2.03 SINGLE CONDUCTOR BUILDING WIRE

- A. Manufacturers:
  - 1. Copper Building Wire:
    - a. Cerro Wire LLC: www.cerrowire.com.
    - b. Southwire Company: www.southwire.com.
    - c. Houston Wire & Cable co.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: Single conductor insulated wire.
- C. Conductor Stranding:
  - 1. Feeders and Branch Circuits:
    - a. Size 10 AWG and Smaller: Solid.
    - b. Size 8 AWG and Larger: Stranded.
  - 2. Control Circuits: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation:
  - 1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.
    - a. Size 4 AWG and Larger: Type XHHW-2.
    - b. Fixture Wiring Within Luminaires: Type TFFN/TFN for luminaires with labeled maximum temperature of 90 degrees C; Approved suitable type for luminaires with labeled maximum temperature greater than 90 degrees C.

## 2.04 UNDERGROUND FEEDER AND BRANCH-CIRCUIT CABLE

- A. Manufacturers:
  - 1. Cerro Wire LLC: www.cerrowire.com.
  - 2. Southwire Company: www.southwire.com.
  - 3. Houston Wire & Cable co..
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: NFPA 70, Type UF multiple-conductor cable listed and labeled as complying with UL 493, Type UF-B.

- C. Provide equipment grounding conductor unless otherwise indicated.
- D. Conductor Stranding:
  - 1. Size 10 AWG and Smaller: Solid.
  - 2. Size 8 AWG and Larger: Stranded.
- E. Insulation Voltage Rating: 600 V.

## 2.05 SERVICE ENTRANCE CABLE

- A. Conductor Stranding: Stranded.
- B. Insulation Voltage Rating: 600 V.

## 2.06 ARMORED CABLE

- A. Manufacturers:
  - 1. AFC Cable Systems Inc: www.afcweb.com.
  - 2. Encore Wire Corporation: www.encorewire.com.
  - 3. Southwire Company: www.southwire.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: NFPA 70, Type AC cable listed and labeled as complying with UL 4, and listed for use in classified firestop systems to be used.
- C. Conductor Stranding:
  - 1. Size 10 AWG and Smaller: Solid.
  - 2. Size 8 AWG and Larger: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation: Type THHN.
- F. Grounding: Combination of interlocking armor and integral bonding wire.
  - 1. Provide additional full-size integral insulated equipment grounding conductor for redundant grounding, suitable for general purpose, non-essential electrical systems in non-hazardous patient care areas of health care facilities.
- G. Armor: Steel, interlocked tape.

## 2.07 METAL-CLAD CABLE

- A. Manufacturers:
  - 1. AFC Cable Systems Inc: www.afcweb.com.
  - 2. Encore Wire Corporation: www.encorewire.com.
  - 3. Southwire Company: www.southwire.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.
- C. Conductor Stranding:
  - 1. Size 10 AWG and Smaller: Solid.
  - 2. Size 8 AWG and Larger: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.
- F. Provide dedicated neutral conductor for each phase conductor where indicated or required.
- G. Grounding: Full-size integral equipment grounding conductor.
  1. Provide additional isolated/insulated grounding conductor where indicated or required.
- H. Armor: Steel, interlocked tape.

I. Provide PVC jacket applied over cable armor where indicated or required for environment of installed location.

#### 2.08 WIRING CONNECTORS

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
- B. Connectors for Grounding and Bonding: Comply with Section 26 05 26.
- C. Wiring Connectors for Splices and Taps:
  - 1. Copper Conductors Sizes 10 and under: Use twist-on insulated spring connectors.
  - 2. Copper Conductors Sizes 8 and larger: Use mechanical connectors.
- D. Wiring Connectors for Terminations:
  - 1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
  - 2. Provide compression adapters for connecting conductors to equipment furnished with mechanical lugs when only compression connectors are specified.
  - 3. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
  - 4. Conductors for Control Circuits: Use crimped terminals for all connections.
- E. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- F. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.
- G. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.
  - 1. Manufacturers:
    - a. 3M: www.3m.com.
    - b. Ideal Industries, Inc: www.idealindustries.com.
    - c. NSI Industries LLC: www.nsiindustries.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
- H. Mechanical Connectors: Provide bolted type or set-screw type.
  - 1. Manufacturers:
    - a. Burndy: www.burndy.com.
    - b. Ilsco: www.ilsco.com.
    - c. Thomas & Betts Corporation: www.tnb.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
- I. Crimped Terminals: Nylon-insulated, with insulation grip and terminal configuration suitable for connection to be made.
  - 1. Manufacturers:
    - a. Burndy: www.burndy.com.
    - b. Ilsco: www.ilsco.com.
    - c. Thomas & Betts Corporation: www.tnb.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.

## 2.09 WIRING ACCESSORIES

- A. Electrical Tape:
  - 1. Manufacturers:
    - a. 3M: www.3m.com.

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- b. Plymouth Rubber Europa: www.plymouthrubber.com.
- c. Substitutions: See Section 01 60 00 Product Requirements.
- 2. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
  - a. Product: 3 M.
  - b. Substitutions: See Section 01 60 00 Product Requirements.
- 3. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
  - a. Product: 3 M.
  - b. Substitutions: See Section 01 60 00 Product Requirements.
- 4. Rubber Splicing Electrical Tape: Ethylene Propylene Rubber (EPR) tape, complying with ASTM D4388; minimum thickness of 30 mil; suitable for continuous temperature environment up to 194 degrees F and short-term 266 degrees F overload service.
- 5. Electrical Filler Tape: Rubber-based insulating moldable putty, minimum thickness of 125 mil; suitable for continuous temperature environment up to 176 degrees F.
- 6. Varnished Cambric Electrical Tape: Cotton cambric fabric tape, with or without adhesive, oil-primed and coated with high-grade insulating varnish; minimum thickness of 7 mil; suitable for continuous temperature environment up to 221 degrees F.
- 7. Moisture Sealing Electrical Tape: Insulating mastic compound laminated to flexible, all-weather vinyl backing; minimum thickness of 90 mil.
- B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.
  - 1. Manufacturers:
    - a. 3M: www.3m.com.
    - b. Burndy: www.burndy.com.
    - c. Thomas & Betts Corporation: www.tnb.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
- C. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.
  - 1. Manufacturers:
    - a. Burndy: www.burndy.com.
    - b. Ideal Industries, Inc: www.idealindustries.com.
    - c. Ilsco: www.ilsco.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
- D. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.
  - 1. Manufacturers:
    - a. 3M: www.3m.com.
    - b. American Polywater Corporation: www.polywater.com.
    - c. Ideal Industries, Inc: www.idealindustries.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
- E. Cable Ties: Material and tensile strength rating suitable for application.

## PART 3 EXECUTION

## 3.01 EXAMINATION

A. Verify that interior of building has been protected from weather.

- B. Verify that work likely to damage wire and cable has been completed.
- C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- D. Verify that field measurements are as shown on the drawings.
- E. Verify that conditions are satisfactory for installation prior to starting work.

#### 3.02 PREPARATION

A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

## 3.03 INSTALLATION

- A. Circuiting Requirements:
  - 1. Unless dimensioned, circuit routing indicated is diagrammatic.
  - 2. When circuit destination is indicated and routing is not shown, determine exact routing required.
  - 3. Arrange circuiting to minimize splices.
  - 4. Include circuit lengths required to install connected devices within 10 ft of location shown.
  - 5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
  - 6. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
  - 7. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are shown as separate, combining them together in a single raceway is not permitted.
- B. Install products in accordance with manufacturer's instructions.
- C. Install conductors and cable in a neat and workmanlike manner in accordance with NECA 1.
- D. Install underground feeder and branch-circuit cable (Type UF-B) in accordance with NECA 121.
- E. Install armored cable (Type AC) in accordance with NECA 120.
- F. Install metal-clad cable (Type MC) in accordance with NECA 120.
- G. Installation in Raceway:
  - 1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
  - 2. Pull all conductors and cables together into raceway at same time.
  - 3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
  - 4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- H. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- I. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
- J. Terminate cables using suitable fittings.
  - Armored Cable (Type AC):

1.

- a. Use listed fittings and anti-short, insulating bushings.
- b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.
- 2. Metal-Clad Cable (Type MC):
  - a. Use listed fittings.
  - b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.

- K. Install conductors with a minimum of 12 inches of slack at each outlet.
- L. Where conductors are installed in enclosures for future termination by others, provide a minimum of 5 feet of slack.
- M. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.
- N. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- O. Make wiring connections using specified wiring connectors.
  - 1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
  - 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
  - 3. Do not remove conductor strands to facilitate insertion into connector.
  - 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
  - 5. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
  - 6. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- P. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
  - 1. Dry Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
    - a. For taped connections, first apply adequate amount of rubber splicing electrical tape or electrical filler tape, followed by outer covering of vinyl insulating electrical tape.
    - b. For taped connections likely to require re-entering, including motor leads, first apply varnished cambric electrical tape, followed by adequate amount of rubber splicing electrical tape, followed by outer covering of vinyl insulating electrical tape.
  - 2. Damp Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
    - a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
    - b. For taped connections, follow same procedure as for dry locations but apply outer covering of moisture sealing electrical tape.
  - 3. Wet Locations: Use heat shrink tubing.
- Q. Insulate ends of spare conductors using vinyl insulating electrical tape.
- R. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
- S. Identify conductors and cables in accordance with Section 26 05 53.
- T. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- U. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

#### 3.04 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is required for all conductors. The resistance test for parallel conductors listed as optional is not required.
- D. Correct deficiencies and replace damaged or defective conductors and cables.

## END OF SECTION

# SECTION 26 05 26 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

#### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.
- F. Ground enhancement material.
- G. Ground access wells.
- H. Grounding and bonding components.
- I. Provide all components necessary to complete the grounding system(s) consisting of:
  - 1. Existing metal underground water pipe.
  - 2. Metal frame of the building.
  - 3. Existing metal underground gas piping system.
  - 4. Metal underground gas piping system.

## 1.02 RELATED REQUIREMENTS

- A. Section 26 05 19 Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
- B. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- C. Section 26 56 00 Exterior Lighting: Additional grounding and bonding requirements for pole-mounted luminaires.

## 1.03 REFERENCE STANDARDS

- A. IEEE 81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- B. NECA 1 Standard for Good Workmanship in Electrical Construction.
- C. NEMA GR 1 Grounding Rod Electrodes and Grounding Rod Electrode Couplings.
- D. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- E. NETA STD ATS Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems; International Electrical Testing Association.
- F. NFPA 70 National Electrical Code.
- G. UL 467 Grounding and Bonding Equipment.

## 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Verify exact locations of underground metal water service pipe entrances to building.
  - 2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
  - 3. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install ground rod electrodes until final backfill and compaction is complete.

#### 1.05 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance: 25 ohms.

#### 1.06 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components.
- C. Shop Drawings:
- D. Product Data: Provide for grounding electrodes and connections.
- E. Test Reports: Indicate overall resistance to ground and resistance of each electrode.
- F. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- G. Project Record Documents: Record actual locations of grounding electrode system components and connections.
- H. Project Record Documents: Record actual locations of components and grounding electrodes.

#### 1.07 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Installer Qualifications for Signal Reference Grids: Company with minimum five years documented experience with high frequency grounding systems.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### 1.08 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

## PART 2 PRODUCTS

#### 2.01 GROUNDING AND BONDING REQUIREMENTS

- A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- D. Grounding System Resistance:
  - 1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by StudioJAED. Precipitation within the previous 48 hours does not constitute normally dry conditions.
  - 2. Grounding Electrode System: Not greater than 5 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.

- 3. Between Grounding Electrode System and Major Electrical Equipment Frames, System Neutral, and Derived Neutral Points: Not greater than 0.5 ohms, when tested using "point-to-point" methods.
- E. Grounding Electrode System:
  - 1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
    - a. Provide continuous grounding electrode conductors without splice or joint.
    - b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
  - 2. Metal Underground Water Pipe(s):
    - a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
    - b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
    - c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
  - 3. Metal Building or Structure Frame:
    - a. Provide connection to metal building or structure frame effectively grounded in accordance with NFPA 70 at nearest accessible location.
  - 4. Ground Ring:
    - a. Provide a ground ring encircling the building or structure consisting of bare copper conductor not less than 2 AWG in direct contact with earth, installed at a depth of not less than 30 inches.
    - b. Where location is not indicated, locate ground ring conductor at least 24 inches outside building perimeter foundation.
    - c. Provide ground enhancement material around conductor where indicated.
    - d. Provide connection from ground ring conductor to:
      - 1) Perimeter columns of metal building frame.
      - 2) Ground rod electrodes located as indicated.
  - 5. Ground Rod Electrode(s):
    - a. Provide three electrodes in an equilateral triangle configuration unless otherwise indicated or required.
    - b. Space electrodes not less than 10 feet from each other and any other ground electrode.
    - c. Where location is not indicated, locate electrode(s) at least 5 feet outside building perimeter foundation as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.
    - d. Provide ground access well for each electrode.
  - 6. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
- F. Service-Supplied System Grounding:
  - 1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
  - 2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.

- G. Bonding and Equipment Grounding:
  - 1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
  - 2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
  - 3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
  - 4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
  - 5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
  - 6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
  - 7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
    - a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
    - b. Metal gas piping.
  - 8. Provide bonding for interior metal air ducts.
  - 9. Provide bonding for metal building frame where not used as a grounding electrode.
- H. Isolated Ground System:
  - 1. Where isolated ground receptacles or other isolated ground connections are indicated, provide separate isolated/insulated equipment grounding conductors.
  - 2. Connect isolated/insulated equipment grounding conductors only to separate isolated/insulated equipment ground busses.
  - 3. Connect the isolated/insulated equipment grounding conductors to the solidly bonded equipment ground bus only at the service disconnect or separately derived system disconnect. Do not make any other connections between isolated ground system and normal equipment ground system on the load side of this connection.
- I. Pole-Mounted Luminaires: Also comply with Section 26 56 00.

## 2.02 GROUNDING AND BONDING COMPONENTS

- A. General Requirements:
  - 1. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
  - 2. Provide products listed and labeled as complying with UL 467 where applicable.
- B. Conductors for Grounding and Bonding, in addition to requirements of Section 26 05 19:
  - 1. Use insulated copper conductors unless otherwise indicated.
    - a. Exceptions:
      - 1) Use bare copper conductors where installed underground in direct contact with earth.
      - 2) Use bare copper conductors where directly encased in concrete (not in raceway).
- C. Connectors for Grounding and Bonding:
  - 1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
  - 2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.

- a. Exceptions:
  - 1) Use mechanical connectors for connections to electrodes at ground access wells.
- 3. Unless otherwise indicated, use exothermic welded connections for accessible connections.
  - a. Exceptions:
    - 1) Use exothermic welded connections for connections to metal building frame.
- 4. Manufacturers Mechanical and Compression Connectors:
  - a. Advanced Lightning Technology (ALT): www.altfab.com.
  - b. Burndy: www.burndy.com.
  - c. Thomas & Betts Corporation: www.tnb.com.
  - d. Substitutions: See Section 01 60 00 Product Requirements.
- 5. Manufacturers Exothermic Welded Connections:
  - a. Burndy: www.burndy.com.
  - b. Cadweld, a brand of Erico International Corporation: www.erico.com.
  - c. ThermOweld, a brand of Continental Industries, Inc: www.thermoweld.com.
  - d. Substitutions: See Section 01 60 00 Product Requirements.
- D. Ground Bars:
  - 1. Description: Copper rectangular ground bars with mounting brackets and insulators.
  - 2. Size: As indicated.
  - 3. Holes for Connections: As indicated or as required for connections to be made.
  - 4. Manufacturers:
    - a. Advanced Lightning Technology (ALT): www.altfab.com.
    - b. Erico International Corporation: www.erico.com.
    - c. Harger Lightning & Grounding: www.harger.com.
    - d. ThermOweld, a brand of Continental Industries, Inc: www.thermoweld.com.
    - e. Substitutions: See Section 01 60 00 Product Requirements.
- E. Ground Rod Electrodes:
  - 1. Comply with NEMA GR 1.
  - 2. Material: Copper-bonded (copper-clad) steel.
  - 3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.
  - 4. Manufacturers:
    - a. Advanced Lightning Technology (ALT): www.altfab.com.
    - b. Erico International Corporation: www.erico.com.
    - c. Galvan Industries, Inc: www.galvanelectrical.com.
    - d. Harger Lightning & Grounding: www.harger.com.
    - e. Substitutions: See Section 01 60 00 Product Requirements.
- F. Ground Enhancement Material:
  - 1. Description: Factory-mixed conductive material designed for permanent and maintenance-free improvement of grounding effectiveness by lowering resistivity.
  - 2. Resistivity: Not more than 20 ohm-cm in final installed form.
  - 3. Manufacturers:
    - a. Erico International Corporation: www.erico.com.
    - b. Harger Lightning & Grounding: www.harger.com.
    - c. ThermOweld, a brand of Continental Industries, Inc: www.thermoweld.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
- G. Ground Access Wells:
  - 1. Description: Open bottom round or rectangular well with access cover for testing and inspection; suitable for the expected load at the installed location.

- 2. Size: As required to provide adequate access for testing and inspection, but not less than minimum size requirements specified.
  - a. Round Wells: Not less than 8 inches in diameter.
- 3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 10 inches.
- 4. Cover: Factory-identified by permanent means with word "GROUND".
- 5. Manufacturers:
  - a. Advanced Lightning Technology (ALT): www.altfab.com.
  - b. Erico International Corporation: www.erico.com.
  - c. Harger Lightning & Grounding: www.harger.com.
  - d. ThermOweld, a brand of Continental Industries, Inc: www.thermoweld.com.
  - e. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.03 MANUFACTURERS

- A. Cooper Power Systems: www.cooperpower.com.
- B. Framatome Connectors International: www.fciconnect.com.
- C. Lightning Master Corporation: www.lightningmaster.com.
- D. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.04 CONNECTORS AND ACCESSORIES

- A. Mechanical Connectors: Bronze.
  - 1. Substitutions: See Section 01 60 00 Product Requirements.
- B. Wire: Stranded copper.
- C. Grounding Electrode Conductor: Size to meet NFPA 70 requirements.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as shown on the drawings.
- C. Verify that conditions are satisfactory for installation prior to starting work.
- D. Verify existing conditions prior to beginning work.
- E. Verify that final backfill and compaction has been completed before driving rod electrodes.

## 3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install grounding and bonding system components in a neat and workmanlike manner in accordance with NECA 1.
- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 or provide ground plates.
  - 1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
- D. Make grounding and bonding connections using specified connectors.
  - 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
- 2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
- 3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
- 4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
- 5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- E. Identify grounding and bonding system components in accordance with Section 26 05 53.
- F. Provide bonding to meet requirements described in Quality Assurance.
- G. Equipment Grounding Conductor: Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing. Each of branch circuits and feeder circuits shall have dedicated equipment grounding conductor, sharing this conductor with other grounding conductors is not permitted.

#### 3.03 FIELD QUALITY CONTROL

- A. Perform inspection in accordance with Section 01 40 00.
- B. Inspect and test in accordance with NETA STD ATS except Section 4.
- C. Perform inspections and tests listed in NETA STD ATS, Section 7.13.
- D. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- E. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

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# SECTION 26 05 29 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

A. Support and attachment components for equipment, conduit, cable, boxes, and other electrical work.

## 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 05 50 00 Metal Fabrications: Materials and requirements for fabricated metal supports.
- C. Section 26 05 34 Conduit: Additional support and attachment requirements for conduits.
- D. Section 26 05 37 Boxes: Additional support and attachment requirements for boxes.
- E. Section 26 51 00 Interior Lighting: Additional support and attachment requirements for interior luminaires.
- F. Section 26 56 00 Exterior Lighting: Additional support and attachment requirements for exterior luminaires.

## 1.03 REFERENCE STANDARDS

- A. ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- B. ASTM A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- C. ASTM B633 Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- D. MFMA-4 Metal Framing Standards Publication.
- E. NECA 1 Standard for Good Workmanship in Electrical Construction.
- F. NFPA 70 National Electrical Code.
- G. UL 5B Strut-Type Channel Raceways and Fittings.

## 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
  - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
  - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
  - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
  - 5. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

#### B. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

#### 1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for metal channel (strut) framing systems, non-penetrating rooftop supports, and post-installed concrete and masonry anchors.
- C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.
- D. Installer's Qualifications: Include evidence of compliance with specified requirements.
- E. Product Data: Provide manufacturer's catalog data for fastening systems.
- F. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

#### 1.06 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with applicable building code.
- C. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- D. Installer Qualifications for Powder-Actuated Fasteners (when specified): Certified by fastener system manufacturer with current operator's license.
- E. Installer Qualifications for Field-Welding: As specified in Section 05 50 00.
- F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

## 1.07 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

## PART 2 PRODUCTS

## 2.01 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
  - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
  - 2. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated, where applicable.
  - 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 1.5. Include consideration for vibration, equipment operation, and shock loads where applicable.
  - 4. Do not use products for applications other than as permitted by NFPA 70 and product listing.
  - 5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
    - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
    - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
    - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

- B. Materials for Metal Fabricated Supports: Comply with Section 05 50 00.
- C. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
  - 1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
  - 2. Conduit Clamps: Bolted type unless otherwise indicated.
  - 3. Manufacturers:
    - a. Cooper Crouse-Hinds, a division of Eaton Corporation: www.cooperindustries.com.
    - b. Erico International Corporation: www.erico.com.
    - c. O-Z/Gedney, a brand of Emerson Industrial Automation: www.emersonindustrial.com.
    - d. Thomas & Betts Corporation: www.tnb.com.
    - e. Substitutions: See Section 01 60 00 Product Requirements.
- D. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.
  - 1. Manufacturers:
    - a. Cooper Crouse-Hinds, a division of Eaton Corporation: www.cooperindustries.com.
    - b. Erico International Corporation: www.erico.com.
    - c. O-Z/Gedney, a brand of Emerson Industrial Automation: www.emersonindustrial.com.
    - d. Thomas & Betts Corporation: www.tnb.com.
    - e. Substitutions: See Section 01 60 00 Product Requirements.
- E. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
  - 1. Comply with MFMA-4.
  - 2. Channel (Strut) Used as Raceway (only where specifically indicated): Listed and labeled as complying with UL 5B.
  - 3. Channel Material:
    - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
    - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
  - 4. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch.
  - 5. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.
  - 6. Manufacturers:
    - a. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com.
    - b. Thomas & Betts Corporation: www.tnb.com.
    - c. Unistrut, a brand of Atkore International Inc: www.unistrut.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
    - e. Source Limitations: Furnish channels (struts) and associated fittings, accessories, and hardware produced by a single manufacturer.
- F. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
  - 1. Minimum Size, Unless Otherwise Indicated or Required:
    - a. Equipment Supports: 1/2 inch diameter.
    - b. Single Conduit up to 1 inch (27mm) trade size: 1/4 inch diameter.
    - c. Single Conduit larger than 1 inch (27mm) trade size: 3/8 inch diameter.
    - d. Trapeze Support for Multiple Conduits: 3/8 inch diameter.
    - e. Outlet Boxes: 1/4 inch diameter.
    - f. Luminaires: 1/4 inch diameter.
- G. Anchors and Fasteners:
  - 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
  - 2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.

- 3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
- 4. Hollow Masonry: Use toggle bolts.
- 5. Hollow Stud Walls: Use toggle bolts.
- 6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
- 7. Sheet Metal: Use sheet metal screws.
- 8. Powder-actuated fasteners are not permitted.
- 9. Hammer-driven anchors and fasteners are not permitted.
- 10. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
  - a. Comply with MFMA-4.
  - b. Channel Material: Use galvanized steel.
  - c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

#### 2.02 MANUFACTURERS

- A. Thomas & Betts Corporation: www.tnb.com.
- B. Threaded Rod Company: www.threadedrod.com.
- C. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.03 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. Anchors and Fasteners:
  - 1. Do not use powder-actuated anchors.
  - 2. Obtain permission from StudioJAED before using powder-actuated anchors.
  - 3. Concrete Structural Elements: Use precast inserts.
  - 4. Steel Structural Elements: Use beam clamps.
  - 5. Concrete Surfaces: Use self-drilling anchors or expansion anchors.
  - 6. Hollow Masonry, Plaster, and Gypsum Board Partitions: Use hollow wall fasteners.
  - 7. Solid Masonry Walls: Use expansion anchors.
  - 8. Sheet Metal: Use sheet metal screws.
  - 9. Wood Elements: Use wood screws.
- D. Formed Steel Channel:
  - 1. Product: manufactured by [B-Line.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.

## PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

## 3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install support and attachment components in a neat and workmanlike manner in accordance with NECA 1.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

- D. Unless specifically indicated or approved by StudioJAED, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by StudioJAED, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
  - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
  - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
  - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
  - 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H. Conduit Support and Attachment: Also comply with Section 26 05 34.
- I. Box Support and Attachment: Also comply with Section 26 05 37.
- J. Interior Luminaire Support and Attachment: Also comply with Section 26 51 00.
- K. Exterior Luminaire Support and Attachment: Also comply with Section 26 56 00.
- L. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- M. Secure fasteners according to manufacturer's recommended torque settings.
- N. Remove temporary supports.
- O. Identify independent electrical component support wires above accessible ceilings (only where specifically indicated or permitted) with color distinguishable from ceiling support wires in accordance with NFPA 70.

## 3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

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# SECTION 26 05 34 CONDUIT

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Galvanized steel rigid metal conduit (RMC).
- B. Flexible metal conduit (FMC).
- C. Liquidtight flexible metal conduit (LFMC).
- D. Electrical metallic tubing (EMT).
- E. Rigid polyvinyl chloride (PVC) conduit.
- F. Conduit fittings.
- G. Accessories.
- H. Conduit, fittings and conduit bodies.

## 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Concrete encasement of conduits.
- B. Section 07 84 00 Firestopping.
- C. Section 26 05 19 Low-Voltage Electrical Power Conductors and Cables: Metal clad cable (Type MC), armored cable (Type AC), and manufactured wiring systems, including uses permitted.
- D. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- E. Section 26 05 29 Hangers and Supports for Electrical Systems.
- F. Section 26 0553 Identification for Electrical Systems.
- G. Section 26 05 37 Boxes.
- H. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- I. Section 31 23 16 Excavation.
- J. Section 31 23 16.13 Trenching: Excavating, bedding, and backfilling.

## 1.03 REFERENCE STANDARDS

- A. ANSI C80.1 American National Standard for Electrical Rigid Steel Conduit (ERSC).
- B. ANSI C80.3 American National Standard for Steel Electrical Metallic Tubing (EMT).
- C. ANSI C80.5 American National Standard for Electrical Rigid Aluminum Conduit (ERAC).
- D. NECA 1 Standard for Good Workmanship in Electrical Construction.
- E. NECA 101 Standard for Installing Steel Conduits (Rigid, IMC, EMT).
- F. NECA 111 Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC).
- G. NEMA FB 1 Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
- H. NFPA 70 National Electrical Code.
- I. UL 1 Flexible Metal Conduit.
- J. UL 6 Electrical Rigid Metal Conduit-Steel.
- K. UL 360 Liquid-Tight Flexible Steel Conduit.
- L. UL 514B Conduit, Tubing, and Cable Fittings.

- M. UL 651 Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
- N. UL 797 Electrical Metallic Tubing-Steel.

## 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
  - 2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
  - 3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
  - 4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.
  - 5. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.
- C. Shop Drawings:
  - 1. Indicate proposed arrangement for conduits to be installed within structural concrete slabs, where permitted.
  - 2. Include proposed locations of roof penetrations and proposed methods for sealing.
- D. Project Record Documents: Record actual routing for conduits installed underground, conduits embedded within concrete slabs, and conduits 2 inch (53 mm) trade size and larger.
- E. Product Data: Provide for metallic conduit and flexible metal conduit.
- F. Samples of Materials Actually Delivered to Site:
  - 1. Two pieces each of conduit, 2 feet long.
- G. Project Record Documents: Accurately record actual routing of conduits larger than 2 inches.

## 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- D. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for purpose specified and shown.

## 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.
- B. Accept conduit on site. Inspect for damage.

- C. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.
- D. Protect PVC conduit from sunlight.

## PART 2 PRODUCTS

## 2.01 CONDUIT APPLICATIONS

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70 and product listing.
- B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
  - 1. Under Slab on Grade: Use rigid PVC conduit.
  - 2. Exterior, Direct-Buried: Use rigid PVC conduit.
  - 3. Exterior, Embedded Within Concrete: Use rigid PVC conduit.
  - 4. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground.
  - 5. Where rigid polyvinyl (PVC) conduit larger than 2 inch (53 mm) trade size is provided, use galvanized steel rigid metal conduit elbows for bends.
- D. Embedded Within Concrete:
- E. Concealed Within Masonry Walls: Use galvanized steel rigid metal conduit.
- F. Concealed Within Hollow Stud Walls: Use electrical metallic tubing (EMT).
- G. Concealed Above Accessible Ceilings: Use electrical metallic tubing (EMT).
- H. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.
- I. Exposed, Interior, Not Subject to Physical Damage: Use galvanized steel rigid metal conduit.
- J. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit.
  - 1. Locations subject to physical damage include, but are not limited to:
    - a. Where exposed below 8 feet, except within electrical and communication rooms or closets.
- K. Exposed, Exterior: Use galvanized steel rigid metal conduit.
- L. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit.
- M. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.
  - 1. Maximum Length: 6 feet.
- N. Connections to Vibrating Equipment:
  - 1. Dry Locations: Use flexible metal conduit.
  - 2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
  - 3. Maximum Length: 6 feet unless otherwise indicated.
  - 4. Vibrating equipment includes, but is not limited to:
    - a. Transformers.
    - b. Motors.
    - c. HVAC equipment.
- O. Fished in Existing Walls, Where Necessary: Use flexible metal conduit.

# 2.02 CONDUIT REQUIREMENTS

A. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.

- B. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
- C. Minimum Conduit Size, Unless Otherwise Indicated:
  - 1. Branch Circuits: 3/4 inch (21 mm) trade size.
    - 2. Branch Circuit Homeruns: 3/4 inch (21 mm) trade size.
    - 3. Control Circuits: 1/2 inch (16 mm) trade size.
    - 4. Flexible Connections to Luminaires: 1/2 inch (16 mm) trade size.
    - 5. Underground, Interior: 3/4 inch (21 mm) trade size.
    - 6. Underground, Exterior: 1 inch (27 mm) trade size.
- D. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

## 2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A. Manufacturers:
  - 1. Allied Tube & Conduit: www.alliedeg.com.
  - 2. Republic Conduit: www.republic-conduit.com.
  - 3. Wheatland Tube Company: www.wheatland.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- C. Fittings:
  - 1. Manufacturers:
    - a. Bridgeport Fittings Inc: www.bptfittings.com.
    - b. O-Z/Gedney, a brand of Emerson Industrial Automation: www.emersonindustrial.com.
    - c. Thomas & Betts Corporation: www.tnb.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
  - 2. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 3. Material: Use steel or malleable iron.
  - 4. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

#### 2.04 METAL CONDUIT

- A. Manufacturers:
  - 1. Allied Tube & Conduit: www.alliedtube.com.
  - 2. Beck Manufacturing, Inc: www.beckmfg.com.
  - 3. Wheatland Tube Company: www.wheatland.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. Fittings and Conduit Bodies: NEMA FB 1; material to match conduit.

## 2.05 FLEXIBLE METAL CONDUIT (FMC)

- A. Manufacturers:
  - 1. AFC Cable Systems, Inc: www.afcweb.com.
  - 2. Electri-Flex Company: www.electriflex.com.
  - 3. International Metal Hose: www.metalhose.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: NFPA 70, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.

- C. Fittings:
  - 1. Manufacturers:
    - a. Bridgeport Fittings Inc: www.bptfittings.com.
    - b. O-Z/Gedney, a brand of Emerson Industrial Automation: www.emersonindustrial.com.
    - c. Thomas & Betts Corporation: www.tnb.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
  - Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with 2 UL 514B.
  - Material: Use steel or malleable iron. 3.
- D. Description: Interlocked steel construction.
- E. Fittings: NEMA FB 1.

# 2.06 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. Manufacturers:
  - 1. AFC Cable Systems, Inc; \_\_\_\_\_: www.afcweb.com.
  - 2.
  - Electri-Flex Company; \_\_\_\_\_: www.electriflex.com. International Metal Hose; \_\_\_\_\_: www.metalhose.com. 3.
  - Substitutions: See Section 01 60 00 Product Requirements. 4.
- B. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.
- C. Fittings:
  - Manufacturers: 1.
    - a. Bridgeport Fittings Inc: www.bptfittings.com.
    - b. O-Z/Gedney, a brand of Emerson Industrial Automation: www.emersonindustrial.com.
    - Thomas & Betts Corporation: www.tnb.com. C.
    - Substitutions: See Section 01 60 00 Product Requirements. d.
  - Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with 2. UL 514B.
  - 3. Material: Use steel or malleable iron.

# 2.07 ELECTRICAL METALLIC TUBING (EMT)

- A. Manufacturers:
  - Allied Tube & Conduit; \_\_\_\_: www.alliedeg.com. 1.
  - Republic Conduit: www.republic-conduit.com. 2.
  - Substitutions: See Section 01 60 00 Product Requirements. 3.
- B. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- C. Fittings:
  - 1. Manufacturers:
    - a. Bridgeport Fittings Inc: www.bptfittings.com.
    - b. O-Z/Gedney, a brand of Emerson Industrial Automation: www.emersonindustrial.com.
    - c. Thomas & Betts Corporation: www.tnb.com.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
  - 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 3. Material: Use steel or malleable iron.
  - 4. Connectors and Couplings: Use compression (gland) or set-screw type.

- a. Do not use indenter type connectors and couplings.
- 5. Damp or Wet Locations (where permitted): Use fittings listed for use in wet locations.
- 6. Embedded Within Concrete (where permitted): Use fittings listed as concrete-tight. Fittings that require taping to be concrete-tight are acceptable.

# 2.08 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

- A. Manufacturers:
  - 1. Cantex Inc: www.cantexinc.com.
  - 2. Carlon, a brand of Thomas & Betts Corporation: www.carlon.com.
  - 3. JM Eagle: www.jmeagle.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.
- C. Fittings:
  - 1. Manufacturer: Same as manufacturer of conduit to be connected.
  - 2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

#### 2.09 ACCESSORIES

- A. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.
- B. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- C. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.
- D. Sealing Compound for Sealing Fittings: Listed for use with the particular fittings to be installed.
- E. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that field measurements are as shown on drawings.
- B. Verify that mounting surfaces are ready to receive conduits.
- C. Verify that conditions are satisfactory for installation prior to starting work.
- D. Verify routing and termination locations of conduit prior to rough-in.
- E. Conduit routing is shown on drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

## 3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install conduit in a neat and workmanlike manner in accordance with NECA 1.
- C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
- D. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
- E. Conduit Routing:
  - 1. Unless dimensioned, conduit routing indicated is diagrammatic.
  - 2. When conduit destination is indicated and routing is not shown, determine exact routing required.

- 3. Conceal all conduits unless specifically indicated to be exposed.
- 4. Conduits in the following areas may be exposed, unless otherwise indicated:
  - a. Electrical rooms.
  - b. Mechanical equipment rooms.
  - c. Within joists in areas with no ceiling.
- 5. Arrange conduit to maintain adequate headroom, clearances, and access.
- 6. Arrange conduit to provide no more than the equivalent of four 90 degree bends between pull points.
- 7. Arrange conduit to provide no more than 150 feet between pull points.
- 8. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
- 9. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
- 10. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
  - a. Heaters.
  - b. Hot water piping.
  - c. Flues.
- 11. Group parallel conduits in the same area together on a common rack.
- F. Conduit Support:
  - 1. Secure and support conduits in accordance with NFPA 70 and Section 26 05 29 using suitable supports and methods approved by the authority having jurisdiction.
  - 2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
  - 3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
  - 4. Use conduit strap to support single surface-mounted conduit.
    - a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
  - 5. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
  - 6. Use conduit clamp to support single conduit from beam clamp or threaded rod.
  - 7. Use trapeze hangers assembled from threaded rods and metal channel (strut) with accessory conduit clamps to support multiple parallel suspended conduits.
  - 8. Use of spring steel conduit clips for support of conduits is not permitted.
  - 9. Use of wire for support of conduits is not permitted.
    - a. For securing conduits to studs in hollow stud walls.
    - b. For suspending conduits supported by spring steel conduit clips (only where specifically indicated or permitted).
- G. Connections and Terminations:
  - 1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
  - 2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
  - 3. Use suitable adapters where required to transition from one type of conduit to another.
  - 4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
  - 5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
  - 6. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.

- 7. Secure joints and connections to provide maximum mechanical strength and electrical continuity.
- H. Penetrations:
  - 1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
  - 2. Make penetrations perpendicular to surfaces unless otherwise indicated.
  - 3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
  - 4. Conceal bends for conduit risers emerging above ground.
  - 5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
  - 6. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
  - 7. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
  - 8. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- I. Underground Installation:
  - 1. Provide trenching and backfilling in accordance with Section 31 23 16.13.
  - 2. Minimum Cover, Unless Otherwise Indicated or Required:
    - a. Underground, Exterior: 24 inches.
      - b. Under Slab on Grade: 12 inches to bottom of slab.
  - 3. Provide underground warning tape in accordance with Section 26 05 53 along entire conduit length.
- J. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Section 03 30 00 with minimum concrete cover of 3 inches on all sides unless otherwise indicated.
- K. Hazardous (Classified) Locations: Where conduits cross boundaries of hazardous (classified) locations, provide sealing fittings located as indicated or in accordance with NFPA 70.
- L. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
  - 1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
  - 2. Where conduits are subject to earth movement by settlement or frost.
- M. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
  - 1. Where conduits pass from outdoors into conditioned interior spaces.
  - 2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
- N. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.
- O. Provide grounding and bonding in accordance with Section 26 05 26.
- P. Identify conduits in accordance with Section 26 05 53.

## 3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

- B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C. Correct deficiencies and replace damaged or defective conduits.

#### 3.04 CLEANING

A. Clean interior of conduits to remove moisture and foreign matter.

#### 3.05 PROTECTION

A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

## 3.06 INTERFACE WITH OTHER PRODUCTS

- A. Install conduit to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.
- 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 specified in Section roofing section.

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# SECTION 26 05 35 SURFACE RACEWAYS

#### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Surface raceway systems.
- B. Wireways.

## 1.02 RELATED REQUIREMENTS

- A. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 Hangers and Supports for Electrical Systems.
  1. Includes metal channel (strut) used as raceway.
- C. Section 26 05 34 Conduit.
- D. Section 26 05 37 Boxes.
- E. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- F. Section 26 27 26 Wiring Devices: Receptacles.
- G. Section 27 10 05 Structured Cabling for Voice and Data Inside-Plant: Voice and data jacks.

#### 1.03 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction.
- B. NFPA 70 National Electrical Code.
- C. UL 5 Surface Metal Raceways and Fittings.
- D. UL 111 Outline of Investigation for Multioutlet Assemblies.

## 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the placement of raceways with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 2. Coordinate rough-in locations of outlet boxes provided under Section 26 05 37 and conduit provided under Section 26 05 34 as required for installation of raceways provided under this section.
  - 3. Verify minimum sizes of raceways with the actual conductors and components to be installed.
  - 4. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install raceways until final surface finishes and painting are complete.
  - 2. Do not begin installation of conductors and cables until installation of raceways is complete between outlet, junction and splicing points.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets including dimensions, knockout sizes and locations, materials, fabrication details, finishes, service condition requirements, and accessories.
  - 1. Surface Raceway Systems: Include information on fill capacities for conductors and cables.

#### 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

#### PART 2 PRODUCTS

#### 2.01 RACEWAY REQUIREMENTS

- A. Provide all components, fittings, supports, and accessories required for a complete raceway system.
- B. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
- C. Do not use raceways for applications other than as permitted by NFPA 70 and product listing.

## 2.02 SURFACE RACEWAY SYSTEMS

- A. Manufacturers:
  - 1. Hubbell Incorporated: www.hubbell-wiring.com.
  - 2. Wiremold, a brand of Legrand North America, Inc: www.legrand.us.
  - 3. Substitutions: See Section 01 60 00 Product Requirements.
- B. Surface Metal Raceways: Listed and labeled as complying with UL 5.
- C. Multioutlet Assemblies: Listed and labeled as complying with UL 111.
- D. Metal Channel (Strut) Used as Raceway: Comply with Section 26 05 29.
- E. Type DS-4000 Surface Raceway System:
  - 1. Raceway Type: Two channel, painted steel.
  - 2. Size: 4 3/4" by 1 3/4 " inches.
  - 3. Length: As indicated on the drawings.
  - 4. Color: To be selected by Architect.
  - 5. Accessory Device Boxes: Suitable for the devices to be installed; color to match raceway.
  - 6. Integrated Device Provisions:
    - a. Receptacles:
      - 1) Comply with Section 26 27 26, except for finishes.
      - 2) Configuration: As indicated on the drawings.
      - 3) Color: Match raceway.
      - 4) Spacing: As indicated on the drawings.
    - b. Communications Outlets:
      - 1) Voice and Data Jacks: As specified in Section 27 10 05.
      - 2) Configuration: As indicated on the drawings.
      - 3) Spacing: As indicated on the drawings.
  - 7. Products:
    - a. \_Pass & Seymour.
    - b. Wiremold\_.
    - c. Substitutions: See Section 01 60 00 Product Requirements.
  - 8. Applications:
    - a. Class rooms, Hallways and Labs.

## 2.03 SOURCE QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

SURFACE RACEWAYS 26 05 35 - 2

#### PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that outlet boxes and conduit terminations are installed in proper locations and are properly sized in accordance with NFPA 70 to accommodate raceways.
- C. Verify that mounting surfaces are ready to receive raceways and that final surface finishes are complete, including painting.
- D. Verify that conditions are satisfactory for installation prior to starting work.

#### 3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install raceways in a neat and workmanlike manner in accordance with NECA 1.
- C. Install raceways plumb and level.
- D. Secure and support raceways in accordance with Section 26 05 29 at intervals complying with NFPA 70 and manufacturer's requirements.
- E. Close unused raceway openings.
- F. Provide grounding and bonding in accordance with Section 26 05 26.
- G. Identify raceways in accordance with Section 26 05 53.

#### 3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Inspect raceways for damage and defects.
- C. Surface Raceway Systems with Integrated Devices: Test each wiring device to verify operation and proper polarity.
- D. Correct wiring deficiencies and replace damaged or defective raceways.

#### 3.04 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

## 3.05 PROTECTION

A. Protect installed raceways from subsequent construction operations.

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# SECTION 26 05 37 BOXES

#### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C. Wall and ceiling outlet boxes.
- D. Floor boxes.
- E. Pull and junction boxes.

## 1.02 RELATED REQUIREMENTS

- A. Section 07 84 00 Firestopping.
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 Hangers and Supports for Electrical Systems.
- D. Section 26 27 26 Wiring Devices:
- 1. Wall plates.
- E. Section 26 2716 Electrical Cabinets and Enclosures.
- F. Section 26 2726 Wiring Devices: Wall plates in finished areas, floor box service fittings, fire-rated poke-through fittings, and access floor boxes.

## 1.03 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction.
- B. NECA 130 Standard for Installing and Maintaining Wiring Devices.
- C. NEMA FB 1 Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
- D. NEMA OS 1 Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
- E. NEMA OS 2 Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports.
- F. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- G. NFPA 70 National Electrical Code.
- H. UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations.
- I. UL 50E Enclosures for Electrical Equipment, Environmental Considerations.
- J. UL 508A Industrial Control Panels.
- K. UL 514A Metallic Outlet Boxes.

# 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
  - 4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.

- 5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
- 6. Coordinate the work with other trades to preserve insulation integrity.
- 7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
- 8. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Project Record Documents: Record actual locations and mounting heights of outlet, pull, and junction boxes on project record documents.

## 1.06 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

## PART 2 PRODUCTS

## 2.01 BOXES

- A. General Requirements:
  - 1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
  - 2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
  - 3. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
  - 4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
  - 5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
  - 1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
  - 2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
  - 3. Use suitable concrete type boxes where flush-mounted in concrete.
  - 4. Use suitable masonry type boxes where flush-mounted in masonry walls.
  - 5. Use raised covers suitable for the type of wall construction and device configuration where required.
  - 6. Use shallow boxes where required by the type of wall construction.
  - 7. Do not use "through-wall" boxes designed for access from both sides of wall.
  - 8. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
  - 9. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
  - 10. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
  - 11. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes.
  - 12. Wall Plates: Comply with Section 26 27 26.
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:

- 1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
- 2. NEMA 250 Environment Type, Unless Otherwise Indicated:
- 3. Junction and Pull Boxes Larger Than 100 cubic inches:
- a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.

## 2.02 MANUFACTURERS

- A. Appleton Electric: www.appletonelec.com.
- B. Steel City
- C. Substitutions: Reco, Inc. See Section 01 60 00 Product Requirements.

## 2.03 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. Concrete Ceiling Boxes: Concrete type.
- B. Nonmetallic Outlet Boxes: NEMA OS 2.
- C. Cast Boxes: NEMA FB 1, Type FD, aluminum. Provide gasketed cover by box manufacturer. Provide threaded hubs.
- D. Wall Plates for Finished Areas: As specified in Section 26 2726.

#### 2.04 FLOOR BOXES

- A. Floor Boxes: NEMA OS 1, fully adjustable, \_4 inches deep.
- B. Material: Cast metal.
- C. Shape: Rectangular.
- D. Service Fittings: As specified in Section 26 2726.

## 2.05 PULL AND JUNCTION BOXES

- A. Sheet Metal Boxes: NEMA OS 1, galvanized steel.
- B. Hinged Enclosures: As specified in Section 26 2716.
- C. Surface Mounted Cast Metal Box: NEMA 250, Type 4; flat-flanged, surface mounted junction box:
  - 1. Material: Galvanized cast iron; Cast Aluminum.
  - 2. Cover: Furnish with ground flange, neoprene gasket, and stainless steel cover screws.
- D. In-Ground Cast Metal Box: NEMA 250, Type 6, outside flanged, recessed cover box for flush mounting:
  - 1. Material: Galvanized cast iron; Cast Aluminum.
  - 2. Cover: Nonskid cover with neoprene gasket and stainless steel cover screws.
  - 3. Cover Legend: "ELECTRIC".

## PART 3 EXECUTION

## 3.01 EXAMINATION

## 3.02

- A. Verify that field measurements are as shown on drawings.
- B. Verify that mounting surfaces are ready to receive boxes.
- C. Verify that conditions are satisfactory for installation prior to starting work.
- D. Verify locations of floor boxes and outlets in offices and work areas prior to rough-in.

## 3.03 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Box Supports:
  - 1. Secure and support boxes in accordance with NFPA 70 and Section 26 05 29 using suitable supports and methods approved by the authority having jurisdiction.
  - 2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
- E. Install boxes plumb and level.
- F. Flush-Mounted Boxes:
  - 1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
  - 2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
  - 3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- G. Install boxes as required to preserve insulation integrity.
- H. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- I. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- J. Close unused box openings.
- K. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- L. Provide grounding and bonding in accordance with Section 26 05 26.
- M. Install boxes securely, in a neat and workmanlike manner, as specified in NECA 1.
- N. Install in locations as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and as required by NFPA 70.
- O. Coordinate installation of outlet boxes for equipment connected under Section 26 2717.
- P. Set wall mounted boxes at elevations to accommodate mounting heights indicated.
- Q. Electrical boxes are shown on Drawings in approximate locations unless dimensioned.
  1. Adjust box locations up to 10 feet if required to accommodate intended purpose.
- R. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726.
- S. Maintain headroom and present neat mechanical appearance.
- T. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.
- U. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed luminaire.

- V. Install boxes to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.
- W. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.
- X. Locate outlet boxes to allow luminaires positioned as shown on reflected ceiling plan.
- Y. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.
- Z. Use flush mounting outlet box in finished areas.
- AA. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.
- AB. 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.
- AC. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
- AD. Use stamped steel bridges to fasten flush mounting outlet box between studs.
- AE. Install flush mounting box without damaging wall insulation or reducing its effectiveness.
- AF. Use adjustable steel channel fasteners for hung ceiling outlet box.
- AG. Do not fasten boxes to ceiling support wires.
- AH. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12 inches of box.
- Al. Use gang box where more than one device is mounted together. Do not use sectional box.
- AJ. Use gang box with plaster ring for single device outlets.
- AK. Use cast outlet box in exterior locations exposed to the weather and wet locations.
- AL. Use cast floor boxes for installations in slab on grade; formed steel boxes are acceptable for other installations.
- AM. Set floor boxes level.
- AN. Large Pull Boxes: Use hinged enclosure in interior dry locations, surface-mounted cast metal box in other locations.

#### 3.04 ADJUSTING

- A. Adjust floor boxes flush with finish flooring material.
- B. Adjust flush-mounting outlets to make front flush with finished wall material.
- C. Install knockout closures in unused box openings.

#### 3.05 CLEANING

A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

#### 3.06 PROTECTION

A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

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# SECTION 26 05 53 IDENTIFICATION FOR ELECTRICAL SYSTEMS

#### PART 1 GENERAL

#### **1.01 SECTION INCLUDES**

- A. Electrical identification requirements.
- B. Identification nameplates and labels.
- C. Wire and cable markers.
- D. Voltage markers.
- E. Warning signs and labels.
- F. Field-painted identification of conduit.

## 1.02 RELATED REQUIREMENTS

A. Section 09 90 00 - Painting and Coating.

## 1.03 REFERENCE STANDARDS

- A. ANSI Z535.2 American National Standard for Environmental and Facility Safety Signs.
- B. ANSI Z535.4 American National Standard for Product Safety Signs and Labels.
- C. NFPA 70 National Electrical Code.
- D. UL 969 Marking and Labeling Systems.

#### 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements for submittals procedures.
- B. Product Data: Provide catalog data for nameplates, labels, and markers.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation and installation of product.

#### 1.05 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

#### **1.06 EXTRA MATERIALS**

A. See Section 01 6000 - Product Requirements for additional requirements.

## PART 2 PRODUCTS

## 2.01 IDENTIFICATION REQUIREMENTS

- A. Identification for Equipment:
  - 1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
- B. Identification for Conductors and Cables:
  - 1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 05 19.
  - 2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.

#### 2.02 MANUFACTURERS

- A. Brady Corporation: www.bradycorp.com.
- B. Seton Identification Products: www.seton.com/aec.

- C. HellermannTyton: www.hellermanntyton.com.
- D. Substitutions: See Section 01 60 00 Product Requirements.

## 2.03 IDENTIFICATION NAMEPLATES AND LABELS

- A. Identification Nameplates:
  - 1. Materials:
  - 2. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.
- B. Identification Labels:
  - 1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
  - 2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
- C. Nameplates: Engraved three-layer laminated plastic, black letters on white background.
- D. Locations:
  - 1. Each electrical distribution and control equipment enclosure.
  - 2. Communication cabinets.
  - 3. Disconnect switches, and starters.
- E. 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.

#### 2.04 WIRE AND CABLE MARKERS

- A. Manufacturers:
  - 1. Panduit Corp.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.
- C. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.
- D. Legend: Power source and circuit number or other designation indicated.
- E. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.
- F. Minimum Text Height: 1/8 inch.
- G. Color: Black text on white background unless otherwise indicated.
- H. Description: split sleeve type wire markers.
- I. Locations: Each conductor at panelboard gutters, pull boxes, outlet boxes, and junction boxes each load connection.
- J. Legend:
  - 1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
  - 2. Control Circuits: Control wire number indicated on shop drawings.

## 2.05 VOLTAGE MARKERS

- A. Manufacturers: Panduit Corp
  - 1. Substitutions: See Section 01 60 00 Product Requirements.
- B. Minimum Size:
  - 1. Markers for Equipment: 1 1/8 by 4 1/2 inches.
  - 2. Markers for Conduits: As recommended by manufacturer for conduit size to be identified.

- 3. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.
- 4. Markers for Junction Boxes: 1/2 by 2 1/4 inches.
- C. Legend:
  - 1. Markers for Voltage Identification: Highest voltage present.
  - 2. Markers for System Identification:
    - a. Emergency Power System: Text "EMERGENCY".
    - b. Other Systems: Type of service.
- D. Color: Black text on orange background unless otherwise indicated.
- E. Location: Furnish markers for each conduit longer than 6 feet.
- F. Spacing: 20 feet on center.
- G. Color:
  - 1. 480 Volt System: Brown.
  - 2. 208 Volt System: Yellow.
  - 3. Fire Alarm System: Red.
- H. Legend:
  - 1. 480 Volt System: brown.
  - 2. 208 Volt System: yellow.
  - 3. Fire Alarm System: red.

#### 2.06 WARNING SIGNS AND LABELS

- A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- B. Warning Signs:
  - 1. Materials:
  - 2. Minimum Size: 7 by 10 inches unless otherwise indicated.
- C. Warning Labels:
  - 1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
  - 2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
  - 3. Minimum Size: 2 by 4 inches unless otherwise indicated.

## PART 3 EXECUTION

## 3.01 PREPARATION

- A. Clean surfaces to receive adhesive products according to manufacturer's instructions.
- B. Degrease and clean surfaces to receive nameplates and labels.

#### 3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
  - 1. Surface-Mounted Equipment: Enclosure front.
  - 2. Flush-Mounted Equipment: Inside of equipment door.
  - 3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
  - 4. Elevated Equipment: Legible from the floor or working platform.
  - 5. Interior Components: Legible from the point of access.
  - 6. Conductors and Cables: Legible from the point of access.
- C. Install identification products centered, level, and parallel with lines of item being identified.

- D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.
- E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

## SECTION 26 05 73

#### OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

- A. Short circuit study.
- B. Coordination study and analysis.

#### 1.02 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Study reports, stamped or sealed and signed by study preparer.
- C. Study Report: Submit protective device studies as specified, prior to submission of product data submittals or ordering or fabrication of protective devices.
  - 1. Include stamp or seal and signature of preparing engineer.

# 1.03 PROTECTIVE DEVICE STUDY

- A. Analyze the specific electrical and utilization equipment (according to NEC definition), the actual protective devices to be used, and the actual feeder lengths to be installed.
  - 1. Study Methodology: Comply with requirements and recommendations of NFPA 70, IEEE 399, and IEEE 242.
  - 2. Report: State the methodology and rationale employed in making each type of calculation; identify computer software package(s) used.
- B. One-Line Diagrams: Prepare schematic drawing of electrical distribution system, with all electrical equipment and wiring to be protected by the protective devices; identify nodes on the diagrams for reference on report that includes:
  - 1. Calculated fault impedance, X/R ratios, utility contribution, and short circuit values (asymmetric and symmetric) at the main switchboard bus and all downstream devices containing protective devices.
  - 2. Breaker and fuse ratings.
  - 3. Transformer kVA and voltage ratings, percent impedance, X/R ratios, and wiring connections.
  - 4. Identification of each bus, with voltage.
  - 5. Conduit materials, feeder sizes, actual lengths, and X/R ratios.
- C. Short Circuit Study: Calculate the fault impedance to determine available 3-phase short circuit and ground fault currents at each bus and piece of equipment during normal conditions, alternate operations, emergency power conditions, and other operations that could result in maximum fault conditions.
  - 1. Show fault currents available at key points in the system down to a fault current of 7,000 A at 480 V and 208 V.
  - 2. Include motor contributions in determining the momentary and interrupting ratings of the protective devices.
  - 3. Report: Include all pertinent data used in calculations and for each device include:
    - a. Device identification.
    - b. Protective device.
    - c. Device rating.
    - d. Calculated short circuit current, asymmetrical and symmetrical, and ground fault current.
- D. Coordination Study: Perform an organized time-current analysis of each protective device in series from the individual device back to the primary source, under normal conditions, alternate operations, and emergency power conditions.

- 1. Graphically illustrate that adequate time separation exists between series devices, including upstream primary device.
- 2. Plot the specific time-current characteristics of each protective device on log-log paper.
- 3. Organize plots so that all upstream devices are clearly depicted on one sheet.
- 4. Also show the following on curve plot sheets:
  - a. Device identification.
  - b. Voltage and current transformer ratios for curves.
  - c. 3-phase and 1-phase ANSI damage curves for each transformer.
  - d. No-damage, melting, and clearing curves for fuses.
  - e. Cable damage curves.
  - f. Transformer inrush points.
  - g. Maximum short circuit cutoff point.
  - h. Simple one-line diagram for the portion of the system that each curve plot illustrates.
  - i. Software report for each curve plot, labeled for identification.
- E. Analysis: Determine ratings and settings of protective devices to minimize damage caused by a fault and so that the protective device closest to the fault will open first.
  - 1. Required Ratings and Settings: Derive required ratings and settings of protective devices in consideration of upstream protective device settings and optimize system to ensure selective coordination.
  - 2. Identify any equipment that is underrated as specified.
  - 3. Identify specified protective devices that will not achieve required protection or coordination and cannot be field adjusted to do so, and for which adequate devices would involve a change to the contract sum.
  - 4. In all cases where adequate protection or coordination cannot be achieved at no extra cost to Caesar Rodney School District, provide a discussion of alternatives and logical compromises for best achievable coordination.
- F. Protective Device Rating and Setting Chart: Summarize in tabular format the required characteristics for each protective device based on the analysis; include:
  - 1. Device identification.
  - 2. Relay CT ratios, tap, time dial, and instantaneous pickup.
  - 3. Circuit breaker sensor rating, long-time, short-time, and instantaneous settings, and time bands.
  - 4. Fuse rating and type.
  - 5. Ground fault pickup and time delay.
  - 6. Input level and expected response time at two test points that are compatible with commonly available test equipment and the ratings of the protective device.
  - 7. Highlight all devices that as furnished by Contractor will not achieve required protection.

#### 1.04 QUALITY ASSURANCE

- A. Computer Software for Study Preparation: Use the latest edition of commercially available software utilizing specified methodologies.
- B. Contractor Responsibility: Provide all project-related data needed by study preparer, including equipment, wire sizes, insulation types, conduit types, and actual circuit lengths.
- C. Caesar Rodney School District's Responsibility: Provide data on relevant Caesar Rodney School District power distribution equipment.

# SECTION 26 09 19 ENCLOSED CONTACTORS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. General purpose contactors.
- B. Lighting contactors.

#### 1.02 RELATED REQUIREMENTS

- A. Section 26 05 29 Hangers and Supports for Electrical Systems.
- B. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- C. Section 26 28 13 Fuses.

## 1.03 REFERENCE STANDARDS

- A. NEMA ICS 2 Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts.
- B. NEMA ICS 5 Industrial Control and Systems: Control Circuit and Pilot Devices.
- C. NEMA ICS 6 Industrial Control and Systems: Enclosures.
- D. NEMA KS 1 Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
- E. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- F. NFPA 70 National Electrical Code.

## 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide dimensions, size, voltage ratings and current ratings.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- D. Maintenance Data: Include instructions for replacing and maintaining coil and contacts.

## 1.05 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience and with service facilities within 100 miles of Project.
- C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

## PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Allen-Bradley/Rockwell Automation: www.ab.com.
- B. Eaton Corporation; Cutler-Hammer Products: www.eaton.com.
- C. Schneider Electric; Square D Products: www.schneider-electric.us.
- D. Substitutions: See Section 01 60 00 Product Requirements.

## 2.02 GENERAL PURPOSE CONTACTORS

A. Description: NEMA ICS 2, AC general purpose magnetic contactor.

- B. Coil operating voltage: 120 volts, 60 Hertz.
- C. Poles: As required to match circuit configuration and control function.
- D. Enclosure: NEMA ICS 6, Type 1.
- E. Accessories:
  - 1. Selector Switch: ON/OFF/AUTOMATIC.
  - 2. Indicating Light: RED.
  - 3. Auxiliary Contacts: One, normally open.

#### 2.03 LIGHTING CONTACTORS

- A. Description: NEMA ICS 2, magnetic lighting contactor.
- B. Configuration: Mechanically held, 3 wire control.
- C. Coil operating voltage: 120 volts, 60 Hertz.
- D. Poles: As required to match circuit configuration and control function.
- E. Contact Rating: Match branch circuit overcurrent protection, considering derating for continuous loads.
- F. Enclosure: NEMA ICS 6, Type 1.
- G. Accessories:
  - 1. Selector Switch: ON/OFF/AUTOMATIC.
  - 2. Indicating Light: RED.
  - 3. Auxiliary Contacts: One, normally open.

#### 2.04 ACCESSORIES

- A. Auxiliary Contacts: NEMA ICS 2, 2 normally open contacts in addition to seal-in contact.
- B. Cover Mounted Pilot Devices: NEMA ICS 5, oiltight type.
- C. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.
- D. Pushbuttons: Lockable type.
- E. Indicating Lights: , LED type.
- F. Selector Switches: Rotary type.
- G. Relays: NEMA ICS 2, .
- H. Control Power Transformers: 120 volt secondary, 50 VA minimum, in each enclosed contactor. Provide fused primary and secondary, and bond unfused leg of secondary to enclosure.

#### 2.05 DISCONNECTS

- A. Combination Contactors: Combine contactor with disconnect in common enclosure.
- B. Disconnects: Thermal magnetic circuit breaker with integral thermal and instantaneous magnetic trip in each pole; UL listed.
- C. Disconnects: Fusible switch assembly; NEMA KS 1, enclosed knife switch with externally operable handle. Fuse clips: Designed to accommodate Class R fuses.

## PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Install enclosed contactors where indicated, in accordance with manufacturer's instructions.
- B. Install enclosed contactors plumb. Provide supports in accordance with Section 26 05 29.
- C. Height: 5 ft to operating handle.
- D. Provide fuses for fusible switches; refer to Section 26 28 13 for product requirements.
E. Provide engraved plastic nameplates; refer to Section 26 0553 for product requirements and location.

# 3.02 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Section 01 40 00.
- B. Inspect and test in accordance with NETA STD ATS, except Section 4.
- C. Perform applicable inspections and tests listed in NETA STD ATS, Section 7.16.1.

# END OF SECTION

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# SECTION 26 09 23 LIGHTING CONTROL DEVICES

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Occupancy sensors.
- B. Time switches.
- C. In-wall interval timers.
- D. Outdoor photo controls.
- E. Daylighting controls.

## 1.02 RELATED REQUIREMENTS

- A. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 Hangers and Supports for Electrical Systems.
- C. Section 26 05 37 Boxes.
- D. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 09 19 Enclosed Contactors: Lighting contactors.
- F. Section 26 09 43 Network Lighting Controls Lutron.
- G. Section 26 27 26 Wiring Devices: Devices for manual control of lighting, including wall switches, wall dimmers, fan speed controllers, and wall plates.
- H. Section 26 51 00 Interior Lighting.
- I. Section 26 56 00 Exterior Lighting.
- J. Section 01 91 00 Commissioning
- K. Section 01 91 10 Functional Testing Procedures
- L. Section 23 08 10 Control Systems Commissioning

## 1.03 REFERENCE STANDARDS

- A. ANSI C136.10 American National Standard for Roadway and Area Lighting Equipment -Locking-Type Photocontrol Devices and Mating Receptacles - Physical and Electrical Interchangeability and Testing.
- B. NECA 1 Standard for Good Workmanship in Electrical Construction.
- C. NECA 130 Standard for Installing and Maintaining Wiring Devices.
- D. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- E. NFPA 70 National Electrical Code.
- F. UL 773A Nonindustrial Photoelectric Switches for Lighting Control.
- G. UL 916 Energy Management Equipment.
- H. UL 917 Clock-Operated Switches.
- I. UL 1472 Solid-State Dimming Controls.

# 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the placement of lighting control devices with millwork, furniture, equipment, etc. installed under other sections or by others.

- 2. Coordinate the placement of wall switch occupancy sensors with actual installed door swings.
- 3. Coordinate the placement of occupancy sensors with millwork, furniture, equipment or other potential obstructions to motion detection coverage installed under other sections or by others.
- 4. Coordinate the placement of photo sensors for daylighting controls with windows, skylights, and luminaires to achieve optimum operation. Coordinate placement with ductwork, piping, equipment, or other potential obstructions to light level measurement installed under other sections or by others.
- 5. Notify StudioJAED of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.
- B. Sequencing:
  - 1. Do not install lighting control devices until final surface finishes and painting are complete.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
- C. Shop Drawings:
  - 1. Occupancy Sensors: Provide lighting plan indicating location, model number, and orientation of each occupancy sensor and associated system component.
  - 2. Daylighting Controls: Provide lighting plan indicating location, model number, and orientation of each photo sensor and associated system component.
- D. Field Quality Control Reports.
- E. Manufacturer's Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- F. Operation and Maintenance Data: Include detailed information on device programming and setup.
- G. Project Record Documents: Record actual installed locations and settings for lighting control devices.

## 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

## 1.07 DELIVERY, STORAGE, AND PROTECTION

A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

#### 1.08 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

### 1.09 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for all occupancy sensors.
- C. Provide two year manufacturer warranty for all daylighting controls.

### PART 2 PRODUCTS

### 2.01 ALL LIGHTING CONTROL DEVICES

- A. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- B. Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete operating system.
- C. Products for Switching of Electronic Fluorescent Ballasts: Tested and rated to be suitable for peak inrush currents specified in NEMA 410.

### 2.02 OCCUPANCY SENSORS

- A. Manufacturers:
  - 1. Hubbell Building Automation, Inc: www.hubbellautomation.com
  - 2. Lutron Electronics Company, Inc: www.lutron.com.
  - 3. Sensor Switch Inc: www.sensorswitch.com.
  - 4. WattStopper: www.wattstopper.com.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
  - 6. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.
- B. All Occupancy Sensors:
  - 1. Description: Factory-assembled commercial specification grade devices for indoor use capable of sensing both major motion, such as walking, and minor motion, such as small desktop level movements, according to published coverage areas, for automatic control of load indicated.
  - 2. Sensor Technology:
    - a. Passive Infrared/Ultrasonic Dual Technology Occupancy Sensors: Designed to detect occupancy using a combination of both passive infrared and ultrasonic technologies.
  - 3. Provide LED to visually indicate motion detection with separate color LEDs for each sensor type in dual technology units.
  - 4. Operation: Unless otherwise indicated, occupancy sensor to turn load on when occupant presence is detected and to turn load off when no occupant presence is detected during an adjustable turn-off delay time interval.
  - 5. Dual Technology Occupancy Sensors: Field configurable turn-on and hold-on activation with settings for activation by either or both sensing technologies.
  - 6. Turn-Off Delay: Field adjustable, with time delay settings up to 30 minutes.
  - 7. Sensitivity: Field adjustable.
  - 8. Adaptive Technology: Field selectable; capable of self-adjusting sensitivity and time delay according to conditions.
  - 9. Compatibility (Non-Dimming Sensors): Suitable for controlling incandescent lighting, low-voltage lighting with electronic and magnetic transformers, fluorescent lighting with electronic and magnetic ballasts, and fractional motor loads, with no minimum load requirements.
  - 10. Load Rating for Line Voltage Occupancy Sensors: As required to control the load indicated on the drawings.
- C. Wall Switch Occupancy Sensors:

- 1. All Wall Switch Occupancy Sensors:
  - a. Description: Occupancy sensors designed for installation in standard wall box at standard wall switch mounting height with a field of view of 180 degrees, integrated manual control capability, and no leakage current to load in off mode.
  - b. Operation: Field selectable to operate either as occupancy sensor (automatic on/off) or as vacancy sensor (manual-on/automatic off).
  - c. Manual-Off Override Control: When used to turn off load while in automatic-on mode, unit to revert back to automatic mode after no occupant presence is detected during the delayed-off time interval.
- 2. Passive Infrared/Ultrasonic Dual Technology Wall Switch Occupancy Sensors: Capable of detecting motion within an area of 900 square feet.
  - a. Products:
    - 1) Hubbell Building Automation.
    - 2) Watt Stopper.
    - 3) Sensor switch.
    - 4) Substitutions: See Section 01 60 00 Product Requirements.
- D. Wall Dimmer Occupancy Sensors:
  - 1. General Requirements:
    - a. Description: Occupancy sensors designed for installation in standard wall box at standard wall switch mounting height with a field of view of 180 degrees, integrated dimming control capability, and no leakage current to load in off mode.
    - b. Manual-Off Override Control Capability: When used to turn off load while in automatic-on mode, unit to revert back to automatic mode after no occupant presence is detected during the delayed-off time interval.
    - c. Dimmer: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, and listed as complying with UL 1472; type and rating suitable for load controlled.
    - d. Provide field adjustable dimming preset for occupied state.
- E. Ceiling Mounted Occupancy Sensors:
  - 1. All Ceiling Mounted Occupancy Sensors:
    - a. Description: Low profile occupancy sensors designed for ceiling installation.
    - b. Unless otherwise indicated or required to control the load indicated on the drawings, provide low voltage units, for use with separate compatible accessory power packs.
    - c. Provide field selectable setting for disabling LED motion detector visual indicator.
    - d. Occupancy sensor to be field selectable as either manual-on/automatic-off or automatic on/off.
    - e. Finish: White unless otherwise indicated.
  - 2. Passive Infrared/Ultrasonic Dual Technology Ceiling Mounted Occupancy Sensors:
    - a. Standard Range Sensors: Capable of detecting motion within an area of 2000 sqft at a mounting height of 9 feet, with a field of view of 360 degrees.
      - 1) Products:
        - (a) Hubbell Building Automation.
        - (b) Sensor Switch.
        - (c) Watt Stopper.
        - (d) Substitutions: See Section 01 60 00 Product Requirements.
- F. Power Packs for Low Voltage Occupancy Sensors:
  - 1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage occupancy sensors for switching of line voltage loads.

- 2. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on the drawings.
- 3. Input Supply Voltage: Dual rated for 120/277 V ac.
- 4. Load Rating:
  - a. Incandescent Load: Not less than 15 A.
  - b. Fluorescent Load: Not less than 20 A.
  - c. Motor Load: Not less than 1 HP.

## 2.03 TIME SWITCHES

- A. Manufacturers:
  - 1. Intermatic, Inc: www.intermatic.com.
  - 2. Paragon, a brand of Invensys Controls: www.invensyscontrols.com.
  - 3. Tork, a division of NSI Industries LLC: www.tork.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
  - 5. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.
- B. Digital Electronic Time Switches:
  - 1. Description: Factory-assembled solid state programmable controller with LCD display, listed and labeled as complying with UL 916 or UL 917.
  - 2. Program Capability:
    - a. Astronomic Time Switches: Single channel, capable of different schedule for each day of the week with additional holiday schedule available to override normal schedule for selected days and field-configurable astronomic feature to automatically adjust for seasonal changes in sunrise and sunset times.
  - 3. Schedule Capacity: Not less than 16 programmable on/off operations.
  - 4. Provide automatic daylight savings time and leap year compensation.
  - 5. Provide power outage backup to retain programming and maintain clock.
  - 6. Manual override: Capable of overriding current schedule both permanently and temporarily until next scheduled event.
  - 7. Provide remote photocell input with light level adjustment.
  - 8. Input Supply Voltage: As indicated on the drawings.
  - 9. Output Switch Contact Ratings:
    - a. Resistive Load: Not less than 30 A at 120-277 V ac.
    - b. Tungsten Load: Not less than 5 A at 120 V ac.
    - c. Inductive Load: Not less than 30 A at 120-277 V ac.
    - d. Ballast Load: Not less than 20 A at 120 V ac or 6 A at 277 V ac.
    - e. Motor Load: Not less than 1 HP at 120 V ac or 2 HP at 240 V ac.
  - 10. Provide lockable enclosure; environmental type per NEMA 250 as specified for the following installation locations:
    - a. Indoor clean, dry locations: Type 1.
- C. Electromechanical Time Switches:
  - 1. Description: Factory-assembled controller with motor-operated timing dial mechanism and adjustable trippers for setting on/off operations, listed and labeled as complying with UL 917.
  - 2. Program Capability:
    - a. 24-Hour Time Switches: With same schedule for each day of the week and skip-a-day feature to omit selected days.
  - 3. Schedule Capacity:
    - a. 24-Hour Time Switches: Accommodating not less than 12 pairs of selected on/off operations per day.

- 4. Manual override: Capable of overriding current schedule both permanently and temporarily until next scheduled event.
- 5. Input Supply Voltage: As indicated on the drawings.
- 6. Output Switch Configuration: As required to control the load indicated on the drawings.
- 7. Output Switch Configuration: SPST dry unpowered maintained contacts.
- 8. Output Switch Contact Ratings: As required to control the load indicated on the drawings.
- 9. Output Switch Contact Ratings:
  - a. Resistive Load: Not less than 40 A at 120-277 V ac.
  - b. Tungsten Load: Not less than 40 A at 120 V ac.
  - c. Inductive Load: Not less than 20 A at 120-277 V ac.
  - d. Motor Load: Not less than 1 HP at 120 V ac or 2 HP at 240 V ac.
- 10. Provide lockable enclosure; environmental type per NEMA 250 as specified for the following installation locations:

## 2.04 IN-WALL INTERVAL TIMERS

- A. Manufacturers:
  - 1. Intermatic, Inc: www.intermatic.com.
  - 2. Paragon, a brand of Invensys Controls: www.invensyscontrols.com.
  - 3. Tork, a division of NSI Industries LLC: www.tork.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
  - 5. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.
- B. Digital Electronic In-Wall Interval Timers:
  - 1. Description: Factory-assembled solid state programmable controller with LCD display, suitable for mounting in standard wall box, and listed and labeled as complying with UL 916 or UL 917.
  - 2. Program Capability: Designed to turn load off at end of preset time interval.
  - 3. Time Interval: Field selectable range of presets available up to 12 hours.
  - 4. Provide field selectable audible and visual indication to warn that end of interval operation is about to turn off load.
  - 5. Provide power outage backup to retain programming and maintain clock.
  - 6. Manual override: Capable of both turning load off and resetting timer to original preset time interval.
  - 7. Switch Configuration: Suitable for use in either SPST or 3-way application.
  - 8. Contact Ratings:
    - a. Resistive Load: Not less than 20 A at 120-277 V ac.
    - b. Tungsten Load: Not less than 15 A at 120 V ac.
    - c. Ballast Load: Not less than 16 A at 120-277 V ac.
    - d. Motor Load: Not less than 1 HP at 120 V ac or 2 HP at 240 V ac.
- C. Spring Wound In-Wall Interval Timers:
  - 1. Description: Factory-assembled controller with mechanical spring wound timing mechanism requiring no electricity to operate; suitable for mounting in standard wall box; rotary control operator with matching wall plate factory marked with time interval units; listed and labeled as complying with UL 916 or UL 917.
  - 2. Program Capability: Designed to turn load off at end of preset time interval.
  - 3. Time Interval: User selectable from zero up to 15 minutes.
  - 4. Manual override: Provide hold feature to disable timer for constant on operation.
  - 5. Switch Configuration: SPST.
  - 6. Contact Ratings: As required to control the load indicated on the drawings.
  - 7. Contact Ratings:
    - a. Resistive Load: Not less than 20 A at 120 V ac or 10 A at 277 V ac.

- b. Inductive Load: Not less than 20 A at 120 V ac or 10 A at 277 V ac.
- c. Tungsten Load: Not less than 7 A at 120 V ac.
- d. Motor Load: Not less than 1 HP at 120 V ac or 2 HP at 250 V ac.

### 2.05 OUTDOOR PHOTO CONTROLS

- A. Manufacturers:
  - 1. Intermatic, Inc: www.intermatic.com.
  - 2. Paragon, a brand of Invensys Controls: www.invensyscontrols.com.
  - 3. Tork, a division of NSI Industries LLC: www.tork.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Stem-Mounted Outdoor Photo Controls:
  - 1. Description: Direct-wired photo control unit with threaded conduit mounting stem and field-adjustable swivel base, listed and labeled as complying with UL 773A.
  - 2. Housing: Weatherproof, impact resistant polycarbonate.
  - 3. Photo Sensor: Cadmium sulfide.
  - 4. Provide external sliding shield for field adjustment of light level activation.
  - 5. Light Level Activation: 1 to 5 footcandles turn-on and 3 to 1 turn-off to turn-on ratio with delayed turn-off.
  - 6. Voltage: As required to control the load indicated on the drawings.
  - 7. Failure Mode: Fails to the on position.
  - 8. Load Rating: As required to control the load indicated on the drawings.
  - 9. Provide accessory wall-mounting bracket where indicated or as required to complete installation.

### 2.06 DAYLIGHTING CONTROLS

- A. Manufacturers:
  - 1. Hubbell Building Automation, Inc: www.hubbellautomation.com
  - 2. Sensor Switch Inc: www.sensorswitch.com.
  - 3. WattStopper: www.wattstopper.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
  - 5. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.
- B. System Description: Control system consisting of photo sensors and compatible control modules and power packs, contactors, or relays as required for automatic control of load indicated according to available natural light; capable of integrating with occupancy sensors and manual override controls.
- C. Daylighting Control Photo Sensors: Low voltage class 2 photo sensor units with output signal proportional to the measured light level and provision for zero or offset based signal.
  - 1. Sensor Type: Filtered silicon photo diode.
  - 2. Sensor Range:
    - a. Indoor Photo Sensors: 5 to 100 footcandles.
  - 3. Finish: White unless otherwise indicated.
  - 4. Where wired sensors are indicated, wireless sensors are acceptable provided that all components and wiring modifications necessary for proper operation are included.
  - 5. Wireless Daylighting Control Photo Sensors:
    - a. RF Range: 30 feet through typical construction materials.
    - b. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 15, for Class B application.
    - c. Power: Battery-operated with minimum ten-year battery life.
- D. Dimming Photo Sensors: Photo sensor units with integral controller compatible with specified dimming ballasts, for direct continuous dimming of up to 50 ballasts.

- E. Daylighting Control Switching Modules for Low Voltage Sensors: Low voltage class 2 control unit compatible with specified photo sensors, for switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
  - 1. Operation: Unless otherwise indicated, load to be turned on when light level is below selected low set point and load to be turned off when light level is above selected high set point, with a no switching dead band between set points to prevent unwanted cycling.
  - 2. Input Delay: To prevent unwanted cycling due to intermittent light level fluctuations.
  - 3. Control Capability:
    - a. Multi-Zone Switching Modules: Capable of controlling up to three separately programmable channels.
- F. Daylighting Control Switching Modules for Wireless Sensors:
  - 1. Description: Plenum rated, self-contained relay compatible with specified wireless photo sensors for switching of line voltage loads in response to changes in measured light levels according to selected settings.
  - 2. Operation: Unless otherwise indicated, load to be turned on when light level is below selected low set point and load to be turned off when light level is above selected high set point, with a no switching dead band between set points to prevent unwanted cycling.
  - 3. Input Delay: To prevent unwanted cycling due to intermittent light level fluctuations.
  - 4. Control Capability: Capable of controlling one programmable channel.
  - 5. Input Supply Voltage: Dual rated for 120/277 V ac.
  - 6. Load Rating:
    - a. General Purpose Load: Not less than 16 A.
    - b. Motor Load: Not less than 1/2 HP (120V) and 1.5 HP (277V).
- G. Daylighting Control Dimming Modules for Low Voltage Sensors: Low voltage class 2 control unit compatible with specified photo sensors and with specified dimming ballasts, for both continuous dimming of compatible dimming ballasts and switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
  - 1. Operation: Unless otherwise indicated, specified load to be continuously brightened as not enough daylight becomes available and continuously dimmed as enough daylight becomes available.
  - 2. Load to be turned off when available daylight is sufficient to fully dim the load, after the selected time delay.
  - 3. Control Capability: Capable of controlling up to three separately programmable channels, with up to 50 ballasts per channel.
  - 4. Dimming and Fade Rates: Adjustable from 5 to 60 seconds.
  - 5. Cut-Off Delay: Selectable and adjustable from 0 to 20 minutes.
- H. Power Packs for Low Voltage Daylighting Control Modules:
  - 1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage daylighting control modules for switching of line voltage loads. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on the drawings.
  - 2. Input Supply Voltage: Dual rated for 120/277 V ac.
  - 3. Load Ratings: As required to control the load indicated on the drawings.
- I. Accessories:
  - 1. Where indicated, provide compatible accessory wall switches for manual override control.
  - 2. Where indicated, provide compatible accessory wireless controls for manual override control.

- a. Products:
  - 1) Hubbell Biuilding Automaiton.
  - 2) Sensor Switch.
  - 3) Substitutions: See Section 01 60 00 Product Requirements.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.
- F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.
- G. Verify that conditions are satisfactory for installation prior to starting work.

### 3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

#### 3.03 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 26 05 37 as required for installation of lighting control devices provided under this section.
  - 1. Mounting Heights: Unless otherwise indicated, as follows:
    - a. Wall Switch Occupancy Sensors: 48 inches above finished floor.
    - b. In-Wall Time Switches: 48 inches above finished floor.
    - c. In-Wall Interval Timers: 48 inches above finished floor.
  - 2. Orient outlet boxes for vertical installation of lighting control devices unless otherwise indicated.
  - 3. Locate wall switch occupancy sensors on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify StudioJAED to obtain direction prior to proceeding with work.
- C. Install lighting control devices in accordance with manufacturer's instructions.
- D. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- E. Install lighting control devices plumb and level, and held securely in place.
- F. Where required and not furnished with lighting control device, provide wall plate in accordance with Section 26 27 26.
- G. Provide required supports in accordance with Section 26 05 29.
- H. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on

wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

- I. Identify lighting control devices in accordance with Section 26 05 53.
- J. Occupancy Sensor Locations:
  - 1. Location Adjustments: Do not make adjustments to locations without obtaining approval from the StudioJAED.
  - 2. Locate ultrasonic and dual technology passive infrared/ultrasonic occupancy sensors a minimum of 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturer's recommendations, in order to minimize false triggers.
- K. Outdoor Photo Control Locations:
  - 1. Where possible, locate outdoor photo controls with photo sensor facing north. If north facing photo sensor is not possible, install with photo sensor facing east, west, or down.
  - 2. Locate outdoor photo controls so that photo sensors do not face artificial light sources, including light sources controlled by the photo control itself.
- L. Install outdoor photo controls so that connections are weatherproof. Do not install photo controls with conduit stem facing up in order to prevent infiltration of water into the photo control.
- M. Daylighting Control Photo Sensor Locations:
  - 1. Location Adjustments: Do not make adjustments to locations without obtaining approval from the StudioJAED.
  - 2. Unless otherwise indicated, locate photo sensors for closed loop systems to accurately measure the light level controlled at the designated task location, while minimizing the measured amount of direct light from natural or artificial sources such as windows or pendant luminaires.
  - 3. Unless otherwise indicated, locate photo sensors for open loop systems to accurately measure the level of daylight coming into the space, while minimizing the measured amount of lighting from artificial sources.
- N. Lamp Burn-In: Operate lamps at full output for minimum of 100 hours or prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.
- O. Unless otherwise indicated, install power packs for lighting control devices above accessible ceiling or above access panel in inaccessible ceiling near the sensor location.

## 3.04 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Inspect each lighting control device for damage and defects.
- C. Test occupancy sensors to verify proper operation, including time delays and ambient light thresholds where applicable. Verify optimal coverage for entire room or area. Record test results in written report to be included with submittals.
- D. Test time switches to verify proper operation.
- E. Test outdoor photo controls to verify proper operation, including time delays where applicable.
- F. Test daylighting controls to verify proper operation, including light level measurements and time delays where applicable. Record test results in written report to be included with submittals.
- G. Correct wiring deficiencies and replace damaged or defective lighting control devices.

## 3.05 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust occupancy sensor settings to minimize undesired activations while optimizing energy savings, and to achieve desired function as indicated or as directed by StudioJAED.

- C. Where indicated or as directed by Architect, install factory masking material or adjust integral blinders on passive infrared (PIR) and dual technology occupancy sensor lenses to block undesired motion detection.
- D. Adjust time switch settings to achieve desired operation schedule as indicated or as directed by StudioJAED. Record settings in written report to be included with submittals.
- E. Adjust external sliding shields on outdoor photo controls under optimum lighting conditions to achieve desired turn-on and turn-off activation as indicated or as directed by StudioJAED.
- F. Adjust daylighting controls under optimum lighting conditions after all room finishes, furniture, and window treatments have been installed to achieve desired operation as indicated or as directed by Architect. Record settings in written report to be included with submittals. Readjust controls calibrated prior to installation of final room finishes, furniture, and window treatments that do not function properly as determined by StudioJAED.

## 3.06 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

### 3.07 COMMISSIONING

A. See Section 01 91 13 for commissioning requirements.

### 3.08 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of lighting control devices to StudioJAED, and correct deficiencies or make adjustments as directed.

## END OF SECTION

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# SECTION 26 22 00 LOW-VOLTAGE TRANSFORMERS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. General purpose transformers.
- B. K-factor transformers rated for nonlinear loads.

## 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- C. Section 26 05 34 Conduit: Flexible conduit connections.
- D. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 05 34 Conduit: Flexible conduit connections.
- F. Section 26 24 16 Panelboards.

## 1.03 REFERENCE STANDARDS

- A. 10 CFR 431, Subpart K Energy Efficiency Program for Certain Commercial and Industrial Equipment - Distribution Transformers.
- B. IEEE C57.94 IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.
- C. IEEE C57.96 Guide for Loading Dry-Type Distribution and Power Transformers.
- D. NECA 1 Standard for Good Workmanship in Electrical Construction.
- E. NECA 409 Standard for Installing and Maintaining Dry-Type Transformers.
- F. NEMA ST 1 Specialty Transformers (Except General Purpose Type); National Electrical Manufacturers Association.
- G. NEMA ST 20 Dry-Type Transformers for General Applications.
- H. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- I. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- J. NFPA 70 National Electrical Code.
- K. UL 506 Standard for Specialty Transformers.
- L. UL 1561 Standard for Dry-Type General Purpose and Power Transformers.

## **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination: Coordinate the work with placement of support framing and anchors required for mounting of transformers.
- B. NEMA TR-1/ANSI 57.12.51 and 57.12.50
- C. Federal Register US department of Energy, Office of Energy Efficiency and Renewable Energy, 10 CFR Part 30, July 29, 2004. Energy Conservation Program for Commercial and Industrial Equipment, Energy Conservaiton Standards for Distribution Transformers, Proposed Rule.
- D. ANSI/ASHRAE/IESNA 90.1 Energy Efficient Design on New Buildings Except Low- Rise Residential Buildings.

- 1. Transformer selection based on optimizing the combination of no-load, part-load, and full-load losses without compromising operational and reliability requirements for the building.
- E. ANSI/NEMA TP-1 Guide for Determining Energy Efficiency for Distribution Transformers.
  - 1. For Reference only. US DOE deos not consider NEMA TP-1 efficiency levels to reflect low life cycle cost.
- F. ANSI/NEMA TP-2 Standard Test Method for Measuring Energy Consumption of Distribution Transformers.
- G. IEEE C57.110-1998 IEEE Recommended Practice for establishing transformer capability when feeding nonsinusoidal load currents.
  - 1. Transformers losses increase in proportion to the mix of electronic equipment in the overall load fed from transformer.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Include voltage, kVA, impedance, tap configurations, insulation system class and rated temperature rise, efficiency, sound level, enclosure ratings, outline and support point dimensions, weight, required clearances, service condition requirements, and installed features.
- C. Provide linear load efficiency data at 25 %, 35%, 50 %, 75 %, and 100 % full load.
  1. Vibration Isolators: Include attachment method and rated load and deflection.
- D. Shop Drawings: Provide dimensioned plan and elevation views of transformers and adjacent equipment with all required clearances indicated.
- E. Product Data: Provide outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, tap configurations, insulation system type, core and coil material and rated temperature rise.
- F. Test Reports: Indicate loss data, efficiency at 0, 25, 50, 75 and 100 percent rated load, and sound level.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Maintenance Data: Include recommended maintenance procedures and intervals.
- I. Project Record Documents: Record actual locations of transformers.

#### 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- E. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

## 1.08 FIELD CONDITIONS

- A. Ambient Temperature: Do not exceed the following maximum temperatures during and after installation of transformers.
  - 1. Greater than 10 kVA: 104 degrees F maximum.
  - 2. Less than 10 kVA: 77 degrees F maximum.
- B. Ambient Temperature: Do not exceed 86 degrees F average or 104 degrees F maximum measured during any 24 hour period during and after installation of transformers.

## 1.09 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. Schneider Electric; Square D Products; Premium 30 energy efficient: www.schneider-electric.us.
- B. Eaton Electrical/Cutler-Hammer: www.eatonelectrical.com.
- C. GE Industrial: www.geindustrial.com.
- D. Powersmiths International Corp.
- E. Substitutions: See Section 01 60 00 Product Requirements.
- F. Source Limitations: Furnish transformers produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

#### 2.02 ALL TRANSFORMERS

- A. Description: High performance, energy efficient, copper wound transformer with 30 % less loses than NEMA TP\_1. Factory-assembled, dry type transformers for 60 Hz operation designed and manufactured in accordance with NEMA ST 20 and listed and labeled by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- B. Unless noted otherwise, transformer ratings indicated are for continuous loading according to IEEE C57.96 under the following service conditions:
  - 1. Altitude: Less than 3,300 feet.
  - 2. Ambient Temperature:
    - a. Greater than 10 kVA: Not exceeding 104 degrees F.
    - b. Less than 10 kVA: Not exceeding 77 degrees F.
  - 3. Ambient Temperature: Not exceeding 86 degrees F average or 104 degrees F maximum measured during any 24 hour period.
- C. Core: High grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Keep magnetic flux densities substantially below saturation point, even at 10 percent primary overvoltage. Tightly clamp core laminations to prevent plate movement and maintain consistent pressure throughout core length.
- D. Impregnate core and coil assembly with non-hydroscopic thermo-setting varnish to effectively seal out moisture and other contaminants.
- E. Basic Impulse Level: 10 kV.
- F. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.
- G. Isolate core and coil from enclosure using vibration-absorbing mounts.

H. Nameplate: Include transformer connection data, ratings, wiring diagrams, and overload capacity based on rated winding temperature rise.

## 2.03 GENERAL PURPOSE TRANSFORMERS

- A. Description: Self-cooled, two winding transformers listed and labeled as complying with UL 506 or UL 1561; ratings as indicated on the drawings.
- B. Primary Voltage: 480 volts delta, 3 phase.
- C. Secondary Voltage: 208Y/120 volts, 3 phase 4 wire.
- D. Insulation System and Allowable Average Winding Temperature Rise:
  - 1. 15 kVA and Larger: Class 220 degrees C insulation system with 115 degrees C average winding temperature rise.
- E. Coil Conductors: Continuous copper windings with terminations brazed or welded.
- F. Winding Taps:
  - 1. Less than 3 kVA: None.
  - 2. 3 kVA through 15 kVA: Two 5 percent full capacity primary taps below rated voltage.
  - 3. 15 kVA through 300 kVA: Two 2.5 percent full capacity primary taps above and four 2.5 percent full capacity primary taps below rated voltage.
  - 4. 500 kVA and Larger: Two 2.5 percent full capacity primary taps above and two 2.5 percent full capacity primary taps below rated voltage.
- G. Energy Efficiency: DOE 2016 energy efficiency levels.
- H. Sound Levels: Low sound levels at least 5 db less than NEMA ST 20 standard sound levels.
- I. Mounting Provisions:
  - 1. Less than 15 kVA: Suitable for wall mounting.
  - 2. 15 kVA through 75 kVA: Suitable for wall, floor, or trapeze mounting.
  - 3. Larger than 75 kVA: Suitable for floor mounting.
- J. Transformer Enclosure: Comply with NEMA ST 20.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor clean, dry locations: Type 2.
  - 2. Construction: Heavy gage steel.
    - a. Less than 15 kVA: Totally enclosed, non-ventilated.
    - b. 15 kVA and Larger: Ventilated.
  - 3. Finish: Manufacturer's standard grey, suitable for outdoor installations.
  - 4. Provide lifting eyes or brackets.
- K. Accessories:
  - 1. Lug Kits: Sized as required for termination of conductors as indicated on the drawings.
- L. Primary Voltage: 480 volts, 3 phase.
- M. Secondary Voltage: 208Y/120 volts, 3 phase.
- N. Insulation system and average winding temperature rise for rated kVA as follows:
  - 1. 1-15 kVA: Class 185 with 115 degrees C rise, in a 40 C ambient setting.
  - 2. 16-500 kVA: Class 220 with 115 degrees C rise, in a 40 C ambient setting.
- O. Case Temperature: Do not exceed 35 degrees C rise above ambient at warmest point at full load.
- P. Winding Taps:
  - 1. Transformers Less than 15 kVA: Two 5 percent below rated voltage, full capacity taps on primary winding.

- 2. Transformers 15 kVA and Larger: Two 2-1/2% full capacity taps above and below normal primary voltage.
- Q. Sound Levels: NEMA ST 20.
- R. Energy Standard
  - 1. Efficiency at 50% load is at least 0.9% higher than NEMA TP-1 for transformers up to 750 KVA.
- S. Basic Impulse Level: 10 kV
- T. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.
- U. Mounting:
  - 1. 1-15 kVA: Suitable for wall mounting.
  - 2. 16-75 kVA: Suitable for wall mounting.
  - 3. Larger than 75 kVA: Suitable for floor mounting.
- V. Coil Conductors: Continuous copper windings with terminations brazed or welded.
- W. Transformer Enclosure: NEMA ST 20.
  - 1. Type 1.
  - 2. Ventilated.
  - 3. Provide lifting eyes or brackets.
  - 4. All terminals, including those for changing taps, must be readily accessible by removing front cover plates.
- X. Isolate core and coil from enclosure using vibration-absorbing mounts.
- Y. Nameplate: Include transformer connection data and overload capacity based on rated allowable temperature rise.

## 2.04 K-FACTOR TRANSFORMERS RATED FOR NONLINEAR LOADS

- A. Description: Self-cooled, two winding transformers listed and labeled as complying with UL 1561, and designed to supply nonlinear loads to the degree designated by the UL defined K-factor; ratings as indicated on the drawings.
- B. Primary Voltage: 480 volts delta, 3 phase.
- C. Secondary Voltage: 208Y/120 volts, 3 phase.
- D. K-factor Rating: K-4, or higher.
- E. Insulation System and Allowable Average Winding Temperature Rise: Class 220 degrees C insulation system with 115 degrees C average winding temperature rise.
- F. Coil Conductors: Continuous copper windings with terminations brazed or welded. Individually insulate secondary conductors and arrange to minimize hysteresis and eddy current losses at harmonic frequencies. Size secondary neutral conductor at twice the secondary phase conductor ampacity.
- G. Winding Taps: Two 2.5 percent full capacity primary taps above and four 2.5 percent full capacity primary taps below rated voltage.
- H. Neutral Bus: Sized to accommodate twice the rated secondary current.
- I. Energy Efficiency: Comply with DOE 2016 requirements.
- J. Sound Levels: Standard sound levels complying with NEMA ST 20.
- K. Mounting Provisions:
  - 1. Up to 75 kVA: Suitable for wall, floor, or trapeze mounting.
  - 2. Larger than 75 kVA: Suitable for floor mounting.

- L. Electrostatic Shield: Provide grounded copper electrostatic shield between primary and secondary windings to attenuate electrical noise.
- M. Transformer Enclosure: Comply with NEMA ST 20.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor clean, dry locations: Type 2.
  - 2. Construction: Steel, ventilated.
  - 3. Finish: Manufacturer's standard grey, suitable for outdoor installations.
  - 4. Provide lifting eyes or brackets.
- N. Accessories:
  - 1. Mounting Brackets: Provide manufacturer's standard brackets.
  - 2. Lug Kits: Sized as required for termination of conductors as indicated on the drawings.

## 2.05 SOURCE QUALITY CONTROL

- A. Factory test transformers according to NEMA ST 20.
- B. Production test each unit according to NEMA ST 20.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that suitable support frames and anchors are installed where required and that mounting surfaces are ready to receive transformers.
- C. Perform pre-installation tests and inspections on transformers per manufacturer's instructions and as specified in NECA 409. Correct deficiencies prior to installation.
- D. Verify that conditions are satisfactory for installation prior to starting work.

## 3.02 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1.
- B. Install transformers in accordance with manufacturer's instructions.
- C. Install transformers in accordance with NECA 409 and IEEE C57.94.
- D. Use flexible conduit, under the provisions of Section 26 05 34, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- E. Arrange equipment to provide minimum clearances as specified on transformer nameplate and in accordance with manufacturer's instructions and NFPA 70.
- F. Set transformers plumb and level.
- G. Use flexible conduit, under the provisions of Section 26 0534, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- H. Mount wall-mounted transformers using integral flanges or accessory brackets furnished by the manufacturer.
- I. Mount floor-mounted transformers on properly sized 4 inch high concrete pad constructed in accordance with Section 03 30 00.
- J. Mount floor-mounted transformers using vibration isolators suitable for isolating the transformer noise from the building structure.
- K. Mount floor-mounted transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.
- L. Mount trapeze-mounted transformers as indicated.
- M. Provide seismic restraints.

- N. Provide grounding and bonding in accordance with Section 26 05 26.
- O. Remove shipping braces and adjust bolts that attach the core and coil mounting bracket to the enclosure according to manufacturer's recommendations in order to reduce audible noise transmission.
- P. Where not factory-installed, install lugs sized as required for termination of conductors as shown on the drawings.
- Q. Identify transformers in accordance with Section 26 05 53.
- R. Install transformer identification nameplate in accordance with Section 26 0553.

### 3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Perform field inspection, testing, and adjusting in accordance with Section 01 40 00.
- C. Inspect and test in accordance with NETA STD ATS, except Section 4.
- D. Perform inspections and tests listed in NETA STD ATS, Section 7.2.1.1. In addition to the basic requirements of Section 7.2, include the following:
  - 1. Perform turns ratio tests at all tap positions.
  - 2. Verification that as-left tap connections are as specified.
  - 3. Perform excitation-current tests on each phase.
  - 4. Measure the resistance of each winding at each tap connection.
  - 5. Overpotential test on all high- and low-voltage windings-to-ground.

### 3.04 ADJUSTING

- A. Measure primary and secondary voltages and make appropriate tap adjustments.
- B. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

### 3.05 CLEANING

- A. Clean dirt and debris from transformer components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

# END OF SECTION

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# SECTION 26 24 13 SWITCHBOARDS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Switchboards.
- B. Overcurrent protective devices for switchboards.
- C. Switchboard accessories.

### **1.02 RELATED REQUIREMENTS**

- A. Section 03 30 00 Cast-in-Place Concrete: Concrete for supporting foundations and pads.
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 Hangers and Supports for Electrical Systems.
- D. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 05 73 Overcurrent Protective Device Coordination Study: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.
- F. Section 26 27 01 Electrical Service Entrance.
- G. Section 26 28 13 Fuses.
- H. Section 26 43 00 Surge Protective Devices.

### 1.03 REFERENCE STANDARDS

- A. FS W-C-375 Circuit Breakers, Molded Case; Branch Circuit and Service; Federal Specification.
- B. ANSI C12.1 American National Standard Code for Electricity Metering.
- C. ANSI C39.1 American National Standard Requirements for Electrical Analog Indicating Instruments; 1981 (R1992).
- D. IEC 60051-1 Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories Part 1: Definitions and General Requirements Common To All Parts;.
- E. IEC 60051-2 Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories Part 2: Special Requirements for Ammeters and Voltmeters.
- F. IEEE C12.1 American National Standard Code for Electricity Metering; Institute of Electrical and Electronic Engineers; 1988.
- G. IEEE C57.13 IEEE Standard Requirements for Instrument Transformers.
- H. NECA 1 Standard for Good Workmanship in Electrical Construction.
- I. NECA 400 Standard for Installing and Maintaining Switchboards.
- J. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- K. NEMA KS 1 Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
- L. NEMA PB 2 Deadfront Distribution Switchboards.
- M. NEMA PB 2.1 General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less.
- N. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- O. NFPA 70 National Electrical Code.

- P. UL 489 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
- Q. UL 891 Switchboards.
- R. UL 1053 Ground-Fault Sensing and Relaying Equipment.

## 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 4. Coordinate with manufacturer to provide shipping splits suitable for the dimensional constraints of the installation.
  - 5. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Service Entrance Switchboards:
  - 1. Coordinate with Utility Company to provide switchboards with suitable provisions for electrical service and utility metering, where applicable.
  - 2. Coordinate with Caesar Rodney School District to arrange for Utility Company required access to equipment for installation and maintenance.
  - 3. Obtain Utility Company approval of switchboard prior to fabrication.
  - 4. Arrange for inspections necessary to obtain Utility Company approval of installation.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, and other installed components and accessories.
  - 1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.
- C. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
  - 1. Include dimensioned plan and elevation views of switchboards and adjacent equipment with all required clearances indicated.
  - 2. Include wiring diagrams showing all factory and field connections.
  - 3. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
  - 4. Include documentation of listed series ratings.
  - 5. Include documentation demonstrating selective coordination.
- D. Service Entrance Switchboards: Include documentation of Utility Company approval of switchboard.
- E. Product Data: Provide electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of all equipment and components.
- F. Shop Drawings: Indicate front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral, and ground; and switchboard instrument details.

- G. Test Reports: Indicate results of factory production tests.
- H. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- I. Project Record Documents: Record actual locations of switchboards.
- J. Maintenance Data: Include spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.
- K. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
  - 2. Enclosure Keys: Two of each different key.

### 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store switchboards in accordance with manufacturer's instructions, NECA 400, and NEMA PB 2.1.
- B. Store in a clean, dry space having a uniform temperature to prevent condensation (including outdoor switchboards, which are not weatherproof until completely and properly installed). Where necessary, provide temporary enclosure space heaters or temporary power for permanent factory-installed space heaters.
- C. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- D. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.
- E. Deliver in 48 inch maximum width shipping splits, individually wrapped for protection and mounted on shipping skids.
- F. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- G. Handle in accordance with NEMA PB 2.1 and manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

#### **1.08 FIELD CONDITIONS**

A. Maintain field conditions within required service conditions during and after installation.

## PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Switchboards Basis of Design: Schneider Electric co. QED power style switchboard.
- B. Switchboards Other Acceptable Manufacturers:
  - 1. Eaton Corporation: www.eaton.com.
  - 2. General Electric Company: www.geindustrial.com.

- C. Substitutions: See Section 01 60 00 Product Requirements.
- D. Siemens Industry, Inc: www.usa.siemens.com.
- E. Eaton Corporation; Cutler-Hammer Products: www.eaton.com.
- F. Schneider Electric; Square D Products: www.schneider-electric.us.
- G. Substitutions: See Section 01 60 00 Product Requirements.
- H. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.
- I. Source Limitations: Furnish switchboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

## 2.02 SWITCHBOARDS

- A. Provide switchboards consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Description: Dead-front switchboard assemblies complying with NEMA PB 2, and listed and labeled as complying with UL 891; ratings, configurations and features as indicated on the drawings.
- D. Front-Connected Switchboards:
  - 1. Main Device(s): Individually-mounted.
  - 2. Feeder Devices: Panel/group-mounted.
  - 3. Arrangement: Front accessible only (not rear accessible), rear aligned.
  - 4. Gutter Access: Bolted covers.
  - 5. Basis of Design: Schneider Electric QED power style switchboard.
- E. Service Conditions:
  - 1. Provide switchboards and associated components suitable for operation under the following service conditions without derating:
    - a. Altitude: Less than 6,600 feet.
    - b. Ambient Temperature:
      - 1) Switchboards Containing Molded Case or Insulated Case Circuit Breakers: Between 23 degrees F and 104 degrees F.
  - 2. Provide switchboards and associated components suitable for operation at indicated ratings under the service conditions at the installed location.
    - a. Altitude: 1000 feet.
    - b. Ambient Temperature: Between 23 degrees F and 104 degrees F.
- F. Short Circuit Current Rating:
  - 1. Provide switchboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
  - 2. Minimum Rating: 65,000 rms symmetrical amperes.
  - 3. Listed series ratings are acceptable, except where not permitted by motor contribution according to NFPA 70.
  - 4. Label equipment utilizing series ratings as required by NFPA 70.
- G. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

- H. Main Devices: Configure for top or bottom incoming feed as indicated or as required for the installation. Provide separate pull section and/or top-mounted pullbox as indicated or as required to facilitate installation of incoming feed.
- I. Bussing: Sized in accordance with UL 891 temperature rise requirements.
  - 1. Through bus (horizontal cross bus) to be fully rated through full length of switchboard (non-tapered). Tapered bus is not permitted.
  - 2. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
  - 3. Provide solidly bonded equipment ground bus through full length of switchboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
  - 4. Phase and Neutral Bus Material: Copper.
  - 5. Ground Bus Material: Copper.
- J. Conductor Terminations: Suitable for use with the conductors to be installed.
  - 1. Line Conductor Terminations:
    - a. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
    - b. Main and Neutral Lug Type: Mechanical.
  - 2. Load Conductor Terminations:
    - a. Lug Material: Copper, suitable for terminating copper conductors only.
    - b. Lug Type:
      - 1) Provide mechanical lugs unless otherwise indicated.
      - 2) Provide compression lugs where indicated.
- K. Enclosures:
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1 or Type 2 (drip-proof).
  - 2. Finish: Manufacturer's standard unless otherwise indicated.
- L. Future Provisions:
  - 1. Prepare designated spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
  - 2. Arrange and equip through bus and ground bus to accommodate future installation of additional switchboard sections.
- M. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00, list switchboards as a complete assembly including surge protective device.
- N. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
  - 1. Where overcurrent protective devices equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
  - 2. Where accessory ground fault sensing and relaying equipment is used, equip companion overcurrent protective devices with ground-fault shunt trips.
    - a. Use zero sequence or residual ground fault detection method unless otherwise indicated.
    - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
- O. Arc Flash Energy-Reducing Maintenance Switching: For circuit breakers rated 1200 A or higher, provide a local accessory switch with status indicator light that permits selection of a maintenance mode with alternate electronic trip unit settings for reduced fault clearing time.
- P. Caesar Rodney School District Metering:

- 1. Provide microprocessor-based digital electrical metering system including all instrument transformers, wiring, and connections necessary for measurements specified.
- 2. Basis of Design: ION 7350.
- 3. Measured Parameters:
  - a. Voltage (Volts AC): Line-to-line, line-to-neutral for each phase.
  - b. Current (Amps): For each phase and neutral.
  - c. Frequency (Hz).
  - d. Real power (kW): For each phase, 3-phase total.
  - e. Reactive power (kVAR): For each phase, 3-phase total.
  - f. Apparent power (kVA): For each phase, 3-phase total.
  - g. Power factor.
  - h. Current demand.
  - i. Power demand: Real, reactive, and apparent.
- 4. Meter Accuracy: Plus/minus 1.0 percent.
- 5. Features:
  - a. Communications Capability: Compatible with system indicated. Provide all accessories necessary for proper interface.
  - b. Remote monitoring capability via PC.
- Q. Instrument Transformers:
  - 1. Comply with IEEE C57.13.
  - 2. Select suitable ratio, burden, and accuracy as required for connected devices.
  - 3. Current Transformers: Connect secondaries to shorting terminal blocks.
  - 4. Potential Transformers: Include primary and secondary fuses with disconnecting means.
- R. Description: NEMA PB 2 switchboard with electrical ratings and configurations as indicated and specified.
- S. Ratings:
  - 1. Voltage: 120/208; 277/480 volts.
  - 2. Configuration: Three phase, four wire, grounded.
  - 3. Main Bus: 2000 amps.277/480 v, 2000 amps, 208/120v .
  - 4. Integrated Equipment Rating: 100000 rms amperes symmetrical.
- T. Main Section Devices: Individually mounted and compartmented.
- U. Distribution Section Devices: \_Group mounted- double row sections.
- V. Bus Material: Copper with tin plating, standard size.
- W. Bus Connections: Bolted, accessible from front for maintenance.
- X. Fully insulate load side bus bars
- Y. Ground Bus: Extend length of switchboard.
- Z. Insulated Ground Bus: Extend length of switchboard.
- AA. Molded Case Circuit Breakers: Integral thermal and instantaneous magnetic trip in each pole.
  - 1. Provide circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits.
    - 2. Include shunt trip where indicated.
    - 3. Circuit Breakers 1- 400amp and up shall be provided with field repalceable trip unit.
    - 4. All Feeder breakers in 208/120v swithboard shall be series rated for min. of 65 kAIC with 1-pole circuit breakers in all panelboards.All feeder breakers in 480y/277v ,3ph4w switchboard shall be series rated for min. of 65 KAIC.
- AB. Solid-State Molded Case Circuit Breakers: With electronic sensing, timing and tripping circuits for adjustable current settings; UL listed.
  - 1. Ground fault trip, ground fault sensing integral with circuit breaker.

- 2. Instantaneous trip.
- 3. Adjustable short time/ long time trip.
- 4. Stationary mounting.
- 5. Include shunt trip where indicated.
- AC. Line and Load Terminations: Accessible from the front only of the switchboard, suitable for the conductor materials and sizes indicated.
- AD. Ground Fault Sensor: Zero sequence type.
- AE. Ground Fault Relay: Adjustable ground fault sensitivity from 200 to 1200 amperes, time delay adjustable from 0 to 15 seconds. Provide monitor panel with lamp to indicate relay operation, TEST and RESET control switches.Max time delay shall be one second for ground fault currents equal to or greater ethan 3000 amps.
- AF. Future Provisions: Fully equip spaces for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Provide continuous current rating as indicated.
- AG. Enclosure: Type \_NEMA 1-Indoors.
  - 1. Align sections at front and rear.
  - 2. Switchboard Height: 91.5 inches, excluding floor sills, lifting members and pull boxes.
  - 3. Finish: Manufacturer's standard light gray enamel over external surfaces. Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.
  - 4. Structure: Free standing, self supporting, totally front accessible.

### 2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Circuit Breakers:
  - 1. Interrupting Capacity:
    - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.
    - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
    - c. Series Rated Systems: Provide circuit breakers listed in combination with upstream devices to provide interrupting rating not less than the short circuit current rating indicated.
  - 2. Molded Case Circuit Breakers:
    - a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
      - 1) Provide thermal magnetic circuit breakers unless otherwise indicated.
      - 2) Provide electronic trip circuit breakers where indicated.
    - b. Minimum Interrupting Capacity:
      - 1) 14000 rms symmetrical amperes at 240 VAC or 208 VAC.
      - 2) 21000 rms symmetrical amperes at 480 VAC.
    - c. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
      - 1) Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
    - d. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
      - 1) Provide the following field-adjustable trip response settings:
        - (a) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.

- (b) Long time delay.
- (c) Short time pickup and delay.
- (d) Instantaneous pickup.
- (e) Ground fault pickup and delay where ground fault protection is indicated.
- e. Provide the following features and accessories where indicated or where required to complete installation:
  - 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.

### 2.04 SURGE PROTECTIVE DEVICES

A. See Section for factory-installed, internally mounted surge protective devices. List and label switchboards containing surge protective devices as a complete assembly including surge protective device.

## 2.05 POWER METERS

- A. Manufacturers:
  - 1. SQ D ION 7350 or approved equal.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Watt-Hour Meters and Wattmeters: ANSI C12.1, three phase induction type with two stators, each with current and potential coil, rated 5 amperes and 120 volts at 60 Hertz.
  - 1. Meter suitable for connection to 3- and 4-wire circuits.
  - 2. Potential indicating lamps.
  - 3. Adjustments for light and full load, phase balance, and power factor.
  - 4. Digital register.
  - 5. Integral demand indicator.
  - 6. Ratchets to prevent reverse rotation.
  - 7. Removable meter with draw-out test plug.
  - 8. Semi-flush mounted case with matching cover.
  - 9. BACnet gateway to provide connection to building automation system.
- C. Provide meters with appropriate multiplier tags.

#### 2.06 METERING TRANSFORMERS

- A. Manufacturers:
  - 1. Square D or equal.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Current Transformers: IEEE C57.13, 5 ampere secondary, wound; bushing; bar or window type, with single secondary winding and secondary shorting device, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.
- C. Potential Transformers: IEEE C57.13, 120 volt single secondary, disconnecting type with integral fuse mountings, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

### 2.07 SOURCE QUALITY CONTROL

- A. Factory test switchboards according to NEMA PB 2, including the following production (routine) tests on each switchboard assembly or component:
  - 1. Dielectric tests.
  - 2. Mechanical operation tests.
  - 3. Grounding of instrument transformer cases test.
  - 4. Electrical operation and control wiring tests, including polarity and sequence tests.
  - 5. Ground-fault sensing equipment test.
- B. Shop inspect and test switchboard according to NEMA PB 2.

SWITCHBOARDS 26 24 13 - 8 C. Make completed switchboard available for inspection at manufacturer's factory prior to packaging for shipment. Notify Caesar Rodney School District at least 7 days before inspection is allowed.

### PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that the ratings and configurations of the switchboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive switchboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### 3.02 PREPARATION

- A. Provide concrete housekeeping pad under the provisions of Section .
- B. Verify that field measurements are as instructed by manufacturer.

## 3.03 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install switchboards in accordance with NECA 1 (general workmanship), NECA 400, and NEMA PB 2.1.
- C. Arrange equipment to provide required clearances and maintenance access, including accommodations for any drawout devices.
- D. Where switchboard is indicated to be mounted with inaccessible side against wall, provide minimum clearance of 1/2 inch between switchboard and wall.
- E. Provide required support and attachment components in accordance with Section 26 05 29.
- F. Install switchboards plumb and level.
- G. Unless otherwise indicated, mount switchboards on properly sized 4 inch high concrete pad constructed in accordance with Section 03 30 00.
- H. Provide grounding and bonding in accordance with Section 26 05 26.
- I. Install all field-installed devices, components, and accessories.
- J. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- K. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed in accordance with Section 26 05 73.
- L. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- M. Provide filler plates to cover unused spaces in switchboards.
- N. Identify switchboards in accordance with Section 26 05 53.
- O. Install switchboard in locations shown on drawings, according to NEMA PB 2.1.
- P. Install in a neat and workmanlike manner, as specified in NECA 400.
- Q. Tighten accessible bus connections and mechanical fasteners after placing switchboard.
- R. Identify switchboards in accordance with Section 26 05 53.

#### 3.04 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.

- C. Before energizing switchboard, perform insulation resistance testing in accordance with NECA 400 and NEMA PB 2.1.
- D. Perform field inspection and testing in accordance with Section .
- E. Inspect and test in accordance with NETA STD ATS, except Section 4.
- F. Perform inspections and tests listed in NETA STD ATS, Section 7.1.
- G. Molded Case and Insulated Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than 225 amperes. Tests listed as optional are not required.
- H. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
  - 1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.
- I. Meters: Perform inspections and tests listed in NETA ATS, Section 7.11.2.
- J. Instrument Transformers: Perform inspections and tests listed in NETA ATS, Section 7.10.
- K. Test shunt trips to verify proper operation.
- L. Correct deficiencies and replace damaged or defective switchboards or associated components.

# 3.05 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of switchboard covers and doors.
- C. Adjust all operating mechanisms for free mechanical movement.
- D. Tighten bolted bus connections in accordance with manufacturer's instructions.
- E. Adjust circuit breaker trip and time delay settings to values indicated.
- F. Adjust circuit breaker trip and time delay settings to values as instructed by StudioJAED.

# 3.06 CLEANING

- A. See Section 01 74 19 Construction Waste Management and Disposal, for additional requirements.
- B. Clean dirt and debris from switchboard enclosures and components according to manufacturer's instructions.
- C. Touch up scratched or marred surfaces to match original finish.

## 3.07 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 Demonstration and Training, for additional requirements.

## 3.08 PROTECTION

A. Protect installed switchboards from subsequent construction operations.

# END OF SECTION

# SECTION 26 24 16 PANELBOARDS

### PART 1 GENERAL

### 1.01 SECTION INCLUDES

- A. Power distribution panelboards.
- B. Lighting and appliance panelboards.
- C. Overcurrent protective devices for panelboards.

### 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 Hangers and Supports for Electrical Systems.
- D. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 05 73 Overcurrent Protective Device Coordination Study: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.
- F. Section 26 22 00 Low-Voltage Transformers: Small power centers with integral primary breaker, transformer, and panelboard.
- G. Section 26 28 13 Fuses: Fuses for fusible switches and spare fuse cabinets.
- H. Section 26 43 00 Surge Protective Devices.

## 1.03 REFERENCE STANDARDS

- A. FS W-C-375 Circuit Breakers, Molded Case; Branch Circuit and Service; Federal Specification.
- B. NECA 1 Standard for Good Workmanship in Electrical Construction.
- C. NECA 407 Standard for Installing and Maintaining Panelboards.
- D. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- E. NEMA ICS 2 Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts.
- F. NEMA KS 1 Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
- G. NEMA PB 1 Panelboards.
- H. NEMA PB 1.1 General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- I. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- J. NFPA 70 National Electrical Code.
- K. UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations.
- L. UL 50E Enclosures for Electrical Equipment, Environmental Considerations.
- M. UL 67 Panelboards.
- N. UL 98 Enclosed and Dead-Front Switches.
- O. UL 489 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
- P. UL 869A Reference Standard for Service Equipment.

- Q. UL 943 Ground-Fault Circuit-Interrupters.
- R. UL 1053 Ground-Fault Sensing and Relaying Equipment.

## 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
  - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 5. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
  - 1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
  - 1. Include wiring diagrams showing all factory and field connections.
  - 2. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.
- F. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- G. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
  - 2. Panelboard Keys: Two of each different key.

### 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

## 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

## 1.08 FIELD CONDITIONS

- A. Maintain ambient temperature within the following limits during and after installation of panelboards:
  - 1. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.

### **1.09 MAINTENANCE MATERIALS**

- A. See Section 01 6000 Product Requirements, for additional provisions.
- B. Furnish two of each panelboard key.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. Eaton Corporation; Cutler-Hammer Products: www.eaton.com.
- B. General Electric Company: www.geindustrial.com.
- C. Schneider Electric; Square D Products: www.schneider-electric.us.
- D. Substitutions: See Section 01 60 00 Product Requirements.
- E. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

## 2.02 ALL PANELBOARDS

- A. Provide products listed and labeled by Underwriters Laboratories Inc. as suitable for the purpose indicated.
- B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
  - 1. Altitude: Less than 6,600 feet.
  - 2. Ambient Temperature:
    - a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
- C. Short Circuit Current Rating:
  - 1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
  - 2. Listed series ratings are acceptable, except where not permitted by motor contribution according to NFPA 70.
  - 3. Label equipment utilizing series ratings as required by NFPA 70.
- D. Panelboards Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- E. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- F. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.

- G. Bussing: Sized in accordance with UL 67 temperature rise requirements.
  - 1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
  - 2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
  - 3. Provide separate isolated/insulated ground bus where indicated or where isolated grounding conductors are provided.
- H. Conductor Terminations: Suitable for use with the conductors to be installed.
- I. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
  - 2. Boxes: Galvanized steel unless otherwise indicated.
  - a. Provide wiring gutters sized to accommodate the conductors to be installed.
  - 3. Fronts:
    - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
    - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
    - c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
  - 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
  - 5. Metal frame for type written directory
  - 6.
- J. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- K. Panelboard Contactors: Where panelboard contactors are indicated, provide electrically operated, mechanically held magnetic contactor complying with NEMA ICS 2.
  - 1. Ampere Rating: Not less than ampere rating of panelboard bus.
  - 2. Short Circuit Current Rating: Not less than the panelboard short circuit current rating.
  - 3. Coil Voltage: As required for connection to control system indicated.
- L. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
  - 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
- M. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

## 2.03 POWER DISTRIBUTION PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Products:
  - 1. SQ D .
  - 2. General Electric.
  - 3. Eaton Cutler Hammer.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- C. Conductor Terminations:
  - 1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
  - 2. Main and Neutral Lug Type: Mechanical.
- D. Bussing:
  - 1. Phase and Neutral Bus Material: Copper.
  - 2. Ground Bus Material: Copper.
- E. Circuit Breakers:
  - 1. Provide bolt-on type or plug-in type secured with locking mechanical restraints.
  - 2. Provide thermal magnetic circuit breakers unless otherwise indicated.
  - 3. Provide electronic trip circuit breakers where indicated.
- F. Enclosures:
  - 1. Provide surface-mounted enclosures unless otherwise indicated.
  - 2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separate lockable continous hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
  - 3. Provide metal circuit directory holder mounted on inside of door.
- G. Manufacturers:
  - 1. SQ.D or Equal.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- H. Description: NEMA PB 1, circuit breaker type.
- I. Service Conditions:
  - 1. Altitude: 1000 feet.
  - 2. Temperature: 55 degrees F.
- J. Panelboard Bus: Copper, ratings as indicated. Provide copper ground bus in each panelboard.
- K. Minimum integrated short circuit rating: As indicated.
  - 1. 240 Volt Panelboards: 14,000 amperes rms symmetrical (minimum).
  - 2. 480 Volt Panelboards: 21,000 amperes rms symmetrical (minimum).
- L. Molded Case Circuit Breakers: With integral thermal and instantaneous magnetic trip in each pole; UL listed. For air conditioning equipment branch circuits provide circuit breakers UL listed as Type HACR.
- M. Molded Case Circuit Breakers with Current Limiters: With replaceable current limiting elements, in addition to integral thermal and instantaneous magnetic trip in each pole; UL listed.
- N. Circuit Breaker Accessories: Trip units and auxiliary switches as indicated.
- O. Enclosure: NEMA PB 1, Type 1, 5 34" deep, 20" wide, cabinet box. With continued hinge and lock.
- P. Cabinet Front: Surface type, fastened with , hinged door with flush lock, finished in manufacturer's standard gray enamel.

#### 2.04 LIGHTING AND APPLIANCE PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Products:
  - 1. SQD.
  - 2. General Electric.
  - 3. Eaton Cutler Hammer.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- C. Conductor Terminations:
  - 1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
  - 2. Main and Neutral Lug Type: Mechanical.

- D. Bussing:
  - 1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
  - 2. Phase and Neutral Bus Material: Copper.
  - 3. Ground Bus Material: Copper.
- E. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.
- F. Enclosures:
  - 1. Provide surface-mounted or flush-mounted enclosures as indicated.
  - 2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separate lockable continous hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
  - 3. Provide metal circuit directory holder mounted on inside of door.
- G. Manufacturers:
  - 1. SQ.D or Equal.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- H. Description: NEMA PB1, circuit breaker type, lighting and appliance branch circuit panelboard.
- I. Panelboard Bus: Copper, ratings as indicated. Provide copper ground bus in each panelboard; provide insulated ground bus where scheduled.
- J. Minimum Integrated Short Circuit Rating: As indicated.
  - 1. 240 Volt Panelboards: 14,000 amperes rms symmetrical (minimum).
  - 2. 480 Volt Panelboards: 21,000 amperes rms symmetrical (minimum).
- K. Molded Case Circuit Breakers: Thermal magnetic trip circuit breakers, bolt-on type, with common trip handle for all poles; UL listed.
  - 1. Type SWD for lighting circuits.
  - 2. Type HACR for air conditioning equipment circuits.
  - 3. Class A ground fault interrupter circuit breakers where scheduled.
  - 4. Do not use tandem circuit breakers, or miniature circuit breakers.
- L. Enclosure: NEMA PB 1, Type 1.
- M. Cabinet Box: 6 inches deep, 20 inches wide for 240 volt and less panelboards, 20 inches wide for 480 volt panelboards.
- N. Cabinet Front: Flush or Surface cabinet front with concealed trim clamps, concealed hinge, metal directory frame, and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

## 2.05 OVERCURRENT PROTECTIVE DEVICES

- A. Molded Case Circuit Breakers:
  - 1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
  - 2. Interrupting Capacity:
    - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
      - 1) 14000 rms symmetrical amperes at 240 VAC or 208 VAC.
      - 2) 21000 rms symmetrical amperes at 480 VAC.
    - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
    - c. Series Rated Systems: Provide circuit breakers listed in combination with upstream devices to provide interrupting rating not less than the short circuit current rating indicated.

- 3. Conductor Terminations:
  - a. Provide mechanical lugs unless otherwise indicated.
  - b. Lug Material: Copper, suitable for terminating copper conductors only.
- 4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
  - a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
  - b. Provide interchangeable trip units where indicated.
- 5. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
  - a. Provide the following field-adjustable trip response settings:
    - 1) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
    - 2) Long time delay.
    - 3) Short time pickup and delay.
    - 4) Instantaneous pickup.
    - 5) Ground fault pickup and delay where ground fault protection is indicated.
- 6. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
- 7. Provide the following circuit breaker types where indicated:
  - a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
- 8. Provide listed switching duty rated circuit breakers with SWD marking for all branch circuits serving fluorescent lighting.
- 9. Provide listed high intensity discharge lighting rated circuit breakers with HID marking for all branch circuits serving HID lighting.
- 10. Do not use tandem circuit breakers.
- 11. Do not use handle ties in lieu of multi-pole circuit breakers.

## 2.06 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Factory test panelboards according to NEMA PB 1.
- PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### 3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install panelboards securely, in a neat and workmanlike manner in accordance with NECA 1 (general workmanship), NECA 407 (panelboards), and NEMA PB 1.1.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required supports in accordance with Section 26 05 29.
- E. Install panelboards plumb.

- F. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- G. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- H. Mount floor-mounted power distribution panelboards on properly sized 4 inch high concrete pad constructed in accordance with Section 03 30 00.
- I. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.
- J. Provide grounding and bonding in accordance with Section 26 05 26.
  - 1. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on isolated/insulated ground bus.
  - 2. Terminate branch circuit isolated grounding conductors on isolated/insulated ground bus only. Do not terminate on solidly bonded equipment ground bus.
- K. Install all field-installed branch devices, components, and accessories.
- L. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed according to Section 26 05 73.
- M. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- N. Install panelboards in accordance with NEMA PB 1.1 and NECA 1.
- O. Install panelboards plumb. Install recessed panelboards flush with wall finishes, where installed surface mounted secure or anchor panelboard to brick or cinder block wall.
- P. Height: 6 feet to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above floor.
- Q. Provide filler plates to cover unused spaces in panelboards.
- R. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also provide for the following:
  - 1. Emergency and night lighting circuits.
  - 2. Fire detection and alarm circuits.
  - 3. Communications equipment circuits.
  - 4. Intrusion detection and access control system circuits.
  - 5. Video surveillance system circuits.
- S. Identify panelboards in accordance with Section 26 05 53.
- T. Provide computer-generated circuit directory for each lighting and appliance panelboard and each power distribution panelboard provided with a door, clearly and specifically indicating the loads served. Identify spares and spaces.
- U. Provide identification nameplate for each panelboard in accordance with Section 26 0553.
- V. Provide arc flash warning labels in accordance with NFPA 70.
- W. Provide spare conduits out of each recessed panelboard to an accessible location above ceiling. Identify each as SPARE.
  - 1. Minimum spare conduits: 5 empty 1 inch.
- X. Ground and bond panelboard enclosure according to Section 26 0526.

### 3.03 FIELD QUALITY CONTROL

- A. Perform inspection, testing, and adjusting in accordance with Section 01 40 00.
- B. Perform field inspection and testing in accordance with Section 01 4000.
- C. Inspect and test in accordance with NETA STD ATS, except Section 4.

- D. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- E. Test GFCI circuit breakers to verify proper operation.
- F. Test shunt trips to verify proper operation.
- G. Procure services of a qualified manufacturer's representative to observe installation and assist in inspection, testing, and adjusting. Include manufacturer's reports with field quality control submittals.
- H. Correct deficiencies and replace damaged or defective panelboards or associated components.
- I. Perform inspections and tests listed in NETA STD ATS, Section 7.5 for switches, Section 7.6 for circuit breakers.

#### 3.04 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

### 3.05 CLEANING

- A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

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# SECTION 26 27 17 EQUIPMENT WIRING

### PART 1 GENERAL

### 1.01 SECTION INCLUDES

A. Electrical connections to equipment.

### 1.02 RELATED REQUIREMENTS

- A. Section 26 05 34 Conduit.
- B. Section 26 05 19 Low-Voltage Electrical Power Conductors and Cables (600 V and Less).
- C. Section 26 05 37 Boxes.
- D. Section 26 27 26 Wiring Devices.

### 1.03 REFERENCE STANDARDS

- A. NEMA WD 1 General Color Requirements for Wiring Devices.
- B. NEMA WD 6 Wiring Devices Dimensional Specifications.
- C. NFPA 70 National Electrical Code.

#### 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide wiring device manufacturer's catalog information showing dimensions, configurations, and construction.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

#### 1.05 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.

#### 1.06 COORDINATION

- A. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
- B. Determine connection locations and requirements.
- C. Sequence rough-in of electrical connections to coordinate with installation of equipment.
- D. Sequence electrical connections to coordinate with start-up of equipment.

## PART 2 PRODUCTS

#### 2.01 MATERIALS

- A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
  - 1. Colors: Conform to NEMA WD 1.
  - 2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
  - 3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.
  - 4. Product:
  - 5. Substitutions: See Section 01 60 00 Product Requirements.

- B. Disconnect Switches: As specified in Section and in individual equipment sections.
- C. Wiring Devices: As specified in Section 26 27 26.
- D. Flexible Conduit: As specified in Section 26 05 34.
- E. Wire and Cable: As specified in Section 26 05 19.
- F. Boxes: As specified in Section 26 05 37.

## 2.02 EQUIPMENT CONNECTIONS

## PART 3 EXECUTION

## 3.01 EXAMINATION

A. Verify that equipment is ready for electrical connection, wiring, and energization.

## 3.02 ELECTRICAL CONNECTIONS

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
- J. Coolers and Freezers: Cut and seal conduit openings in freezer and cooler walls, floor, and ceilings.

## SECTION 26 27 26 WIRING DEVICES

### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Wall switches.
- B. Wall dimmers.
- C. Receptacles.
- D. Wall plates.
- E. Floor box service fittings.

## 1.02 RELATED REQUIREMENTS

- A. Section 26 05 19 Low-Voltage Electrical Power Conductors and Cables: Manufactured wiring systems for use with access floor boxes with compatible pre-wired connectors.
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- C. Section 26 05 35 Surface Raceways: Surface raceway systems, including multioutlet assemblies.
- D. Section 26 05 37 Boxes.
- E. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- F. Section 26 09 23 Lighting Control Devices: Devices for automatic control of lighting, including occupancy sensors, in-wall time switches, and in-wall interval timers.
- G. Section 26 27 17 Equipment Wiring: Cords and plugs for equipment.
- H. Section 26 29 13 Enclosed Controllers: Manual motor starters and horsepower rated motor-starting switches without overload protection.
- I. Section 27 10 05 Structured Cabling for Voice and Data Inside-Plant: Voice and data jacks.

## 1.03 REFERENCE STANDARDS

- A. FS W-C-596 Connector, Electrical, Power, General Specification for; Federal Specification.
- B. FS W-S-896 Switches, Toggle (Toggle and Lock), Flush-mounted (General Specification); Federal Specification.
- C. NECA 1 Standard for Good Workmanship in Electrical Construction.
- D. NECA 130 Standard for Installing and Maintaining Wiring Devices.
- E. NEMA WD 1 General Color Requirements for Wiring Devices.
- F. NEMA WD 6 Wiring Devices Dimensional Specifications.
- G. NFPA 70 National Electrical Code.
- H. UL 20 General-Use Snap Switches.
- I. UL 498 Attachment Plugs and Receptacles.
- J. UL 514D Cover Plates for Flush-Mounted Wiring Devices.
- K. UL 943 Ground-Fault Circuit-Interrupters.
- L. UL 1472 Solid-State Dimming Controls.

## 1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

- 1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
- 2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
- 3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
- 4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
- 5. Coordinate the core drilling of holes for poke-through assemblies with the work covered under other sections.
- 6. Notify StudioJAED of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.
- B. Sequencing:
  - 1. Do not install wiring devices until final surface finishes and painting are complete.

### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.
- C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- D. Operation and Maintenance Data:
- 1. GFCI Receptacles: Include information on status indicators.
- E. Project Record Documents: Record actual installed locations of wiring devices.
- F. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
  - 2. Extra Wall Plates: One of each style, size, and finish.
  - 3. Extra Flush Floor Service Fittings: Two of each type.

### 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

### 1.07 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

### 1.08 EXTRA MATERIALS

- A. See Section 01 6000 Product Requirements, for additional provisions.
- B. Furnish two of each style, size, and finish wall plate.

### PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. Hubbell Incorporated; : www.hubbell-wiring.com.
- B. Leviton Manufacturing Company, Inc; : www.leviton.com.
- C. Lutron Electronics Company, Inc: www.lutron.com.
- D. Pass & Seymour, a brand of Legrand North America, Inc; : www.legrand.us
- E. Cooper Wiring Devices: www.cooperwiringdevices.com.
- F. Leviton Manufacturing, Inc: www.leviton.com.
- G. Substitutions: See Section 01 60 00 Product Requirements.
- H. Source Limitations: Where possible, for each type of wiring device furnish products produced by a single manufacturer and obtained from a single supplier.

### 2.02 APPLICATIONS

- A. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- C. Provide weather resistant GFI receptacles with specified weatherproof covers for all receptacles installed outdoors or in damp or wet locations.
- D. Provide GFI protection for all receptacles installed within 6 feet of sinks.
- E. Provide GFCI protection for receptacles serving electric drinking fountains.
- F. Unless noted otherwise, do not use combination switch/receptacle devices.
- G. For flush floor service fittings, use carpet flanges for installations in carpeted floors.

#### 2.03 ALL WIRING DEVICES

A. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

#### 2.04 WALL SWITCHES

- A. Manufacturers:
  - 1. Hubbell Incorporated; : www.hubbell-wiring.com.
  - 2. Leviton Manufacturing Company, Inc; : www.leviton.com.
  - 3. Pass & Seymour, a brand of Legrand North America, Inc; : www.legrand.us
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Wall Switches: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20 and where applicable, FS W-S-896; types as indicated on the drawings.
  - 1. Wiring Provisions: Terminal screws for side wiring and screw actuated binding clamp for back wiring with separate ground terminal screw.
- C. Standard Wall Switches: Commercial specification grade, 20 A, 120/277 V with standard toggle type switch actuator and maintained contacts; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.
- D. Wall Switches: Heavy Duty, AC only general-use snap switch, complying with NEMA WD 6 and WD 1.
  - 1. Body and Handle: Black plastic with toggle handle.
  - 2. Ratings:
    - a. Voltage: 120 277 volts, AC.
    - b. Current: 20 amperes.

- 3. Ratings: Match branch circuit and load characteristics.
- E. Switch Types: Single pole, double pole, 3-way, and 4-way.

### 2.05 WALL DIMMERS

- A. Manufacturers:
  - 1. Leviton Manufacturing Company, Inc; \_\_\_\_\_: www.leviton.com.
  - 2. Lutron Electronics Company, Inc; Maestro Series: www.lutron.com.
  - 3. Pass & Seymour, a brand of Legrand North America, Inc; \_\_\_\_\_: www.legrand.us
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Wall Dimmers: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 1472; types and ratings suitable for load controlled as indicated on the drawings.
- C. Control: Slide control type with separate on/off switch.

### 2.06 RECEPTACLES

- A. Manufacturers:
  - 1. Hubbell Incorporated; : www.hubbell-wiring.com.
  - 2. Leviton Manufacturing Company, Inc; : www.leviton.com.
  - 3. Pass & Seymour, a brand of Legrand North America, Inc; : www.legrand.us
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Receptacles: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
  - 1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
  - 2. NEMA configurations specified are according to NEMA WD 6.
- C. Convenience Receptacles:
  - 1. Standard Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
    - a. Products:
      - 1) Hubbell Wiring Devices.
      - 2) Leviton.
      - 3) Pass & Saymore.
      - 4) Substitutions: See Section 01 60 00 Product Requirements.
- D. GFI Receptacles:
  - 1. All GFI Receptacles: Provide with feed-through protection, light to indicate ground fault tripped condition and loss of protection, and list as complying with UL 943, class A.
  - 2. Standard GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
- E. Receptacles: Heavy duty, complying with NEMA WD 6 and WD 1.
  - 1. Device Body: Black plastic.
  - 2. Configuration: NEMA WD 6, type as specified and indicated.
- F. Convenience Receptacles: Type 5 20.
- G. Single Convenience Receptacles.
- H. Duplex Convenience Receptacles.
- I. GFCI Receptacles: Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements.

#### 2.07 TELEPHONE JACKS

- A. Product: AMP manufacturing
- B. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.08 WALL PLATES

- A. Manufacturers:
  - 1. Hubbell Incorporated; : www.hubbell-wiring.com.
  - 2. Leviton Manufacturing Company, Inc; : www.leviton.com.
  - 3. Pass & Seymour, a brand of Legrand North America, Inc; : www.legrand.us
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Wall Plates: Comply with UL 514D.
  - 1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
  - 2. Size: Standard; .
  - 3. Screws: Metal with slotted heads finished to match wall plate finish.
- C. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.
- D. Weatherproof Covers for Damp Locations: Gasketed, cast aluminum, with self-closing hinged cover and corrosion-resistant screws; listed as suitable for use in wet locations with cover closed.
- E. Weatherproof Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.
- F. Decorative Cover Plates: stainless steel.
- G. Jumbo Cover Plates: stainless steel.
- H. Weatherproof Cover Plates: Gasketed cast metal with hinged cover.

### 2.09 FLOOR BOX SERVICE FITTINGS

- A. Manufacturers:
  - 1. Hubbell Incorporated; : www.hubbell-wiring.com.
  - 2. Thomas & Betts Corporation; : www.tnb.com.
  - 3. Wiremold, a brand of Legrand North America, Inc; : www.legrand.us
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: Service fittings compatible with floor boxes provided under Section 26 05 37 with all components, adapters, and trims required for complete installation.
- C. Flush Floor Service Fittings:
  - 1. Dual Service Flush Combination Outlets:
    - a. Cover: Rectangular.
    - b. Configuration:
      - 1) Power: One standard convenience duplex receptacle(s) with duplex flap opening(s).
      - 2) Communications: Two Data Drops.
      - 3) Voice and Data Jacks: As specified in Section 27 10 05.
  - 2. Accessories:
    - a. Carpet Flanges: Finish to match covers; configuration as required to accommodate specified covers.

#### 2.10 POKE-THROUGH ASSEMBLIES

- A. Description: Assembly comprising floor service fitting, poke-through component, fire stops and smoke barriers, and junction box for conduit termination; fire rating listed to match fire rating of floor and suitable for floor thickness where installed.
- B. Flush Floor Service Fittings:
  - 1. Dual Service Flush Combination Outlets:
    - a. Cover: Hinged door(s).
    - b. Configuration:
      - 1) Power: One standard convenience duplex receptacle(s).
      - 2) Communications: Two data drops...
      - 3) Voice and Data Jacks: As specified in Section 27 10 05.
  - 2. Accessories:
    - a. Closure Plugs: Size and fire rating as required to seal unused core hole and maintain fire rating of floor.

#### PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that floor boxes are adjusted properly.
- F. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- G. Verify that openings in access floor are in proper locations.
- H. Verify that conditions are satisfactory for installation prior to starting work.

#### 3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

### 3.03 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Perform work in a neat and workmanlike manner in accordance with NECA 1, including mounting heights specified in that standard unless otherwise indicated.
- C. Coordinate locations of outlet boxes provided under Section 26 05 37 as required for installation of wiring devices provided under this section.
  - 1. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
  - 2. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify StudioJAED to obtain direction prior to proceeding with work.
- D. Install wiring devices in accordance with manufacturer's instructions.
- E. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

- F. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
- G. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.
- H. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- I. For isolated ground receptacles, connect wiring device grounding terminal only to identified branch circuit isolated equipment grounding conductor. Do not connect grounding terminal to outlet box or normal branch circuit equipment grounding conductor.
- J. Unless otherwise indicated, GFCI receptacles may be connected to provide feed-through protection to downstream devices. Label such devices to indicate they are protected by upstream GFCI protection.
- K. Install securely, in a neat and workmanlike manner, as specified in NECA 1.
- L. Install wiring devices plumb and level with mounting yoke held rigidly in place.
- M. Install wall switches with OFF position down.
- N. Do not share neutral conductor on branch circuits utilizing wall dimmers.
- O. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
- P. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- Q. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.
- R. Install poke-through closure plugs in each unused core holes to maintain fire rating of floor.
- S. Install receptacles with grounding pole on top.
- T. Connect wiring device grounding terminal to outlet box with bonding jumper.
- U. Install decorative plates on switch, receptacle, and blank outlets in finished areas.
- V. Connect wiring devices by wrapping conductor around screw terminal.
- W. Use jumbo size plates for outlets installed in masonry walls.
- X. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.

### 3.04 INTERFACE WITH OTHER PRODUCTS

- A. Coordinate locations of outlet boxes provided under Section 26 05 37 to obtain mounting heights.
- B. Install wall switch 48 inches above finished floor.
- C. Install convenience receptacle 18 inches above finished floor.
- D. Install convenience receptacle 6 inches above backsplash of counter.
- E. Install telephone jack 18 inches above finished floor.
- F. Install telephone jack for side-reach wall telephone to position top of telephone at 54 inches above finished floor.
- G. Install telephone jack for forward-reach wall telephone to position top of telephone at 48 inches above finished floor.

- H. Coordinate installation of access floor boxes with access floor system provided under Section 09 6900.
- I. Coordinate the installation of wiring devices with underfloor duct service fittings provided under Section 26 0540.

### 3.05 FIELD QUALITY CONTROL

- A. Perform field inspection, testing, adjusting, and balancing in accordance with Section 01 40 00.
- B. Inspect each wiring device for damage and defects.
- C. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.
- D. Operate each wall switch with circuit energized and verify proper operation.
- E. Verify that each receptacle device is energized.
- F. Test each receptacle to verify operation and proper polarity.
- G. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- H. Correct wiring deficiencies and replace damaged or defective wiring devices.
- I. Verify that each telephone jack is properly connected and circuit is operational.

## 3.06 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

## 3.07 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

# SECTION 26 28 13 FUSES

### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

A. Fuses.

### 1.02 RELATED REQUIREMENTS

- A. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- B. Section 26 05 73 Overcurrent Protective Device Coordination Study: Additional criteria for the selection of protective devices specified in this section.
- C. Section 26 24 13 Switchboards: Fusible switches.
- D. Section 26 24 16 Panelboards: Fusible switches.
- E. Section 26 28 18 Enclosed Switches: Fusible switches.
- F. Section 26 29 13 Enclosed Controllers: Fusible switches.

### 1.03 REFERENCE STANDARDS

- A. NEMA FU 1 Low Voltage Cartridge Fuses.
- B. NFPA 70 National Electrical Code.
- C. UL 248-1 Low-Voltage Fuses Part 1: General Requirements.
- D. UL 248-4 Low-Voltage Fuses Part 4: Class CC Fuses.
- E. UL 248-12 Low-Voltage Fuses Part 12: Class R Fuses.

### 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
    - a. Fusible Switches for Enclosed Motor Controllers: See Section 26 29 13.
  - 2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.
  - 3. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard data sheets including voltage and current ratings, interrupting ratings, time-current curves, and current limitation curves.
- C. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
  - 2. Extra Fuses: One set(s) of three for each type and size installed.
  - 3. Fuse Pullers: One set(s) compatible with each type and size installed.

#### 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience and with service facilities within 100 miles of Project.
- E. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

#### **1.07 MAINTENANCE MATERIALS**

- A. See Section 01 6000 Product Requirements, for additional provisions.
- B. Furnish two fuse pullers.
- C. Furnish three of each size and type fuse installed.

### PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. Cooper Bussmann, a division of Cooper Industries: www.cooperindustries.com.
- B. Mersen (formerly Ferraz Shawmut): ferrazshawmut.mersen.com.
- C. Littelfuse, Inc: www.littelfuse.com.
- D. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 APPLICATIONS

- A. Service Entrance:
  - 1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
- B. General Purpose Branch Circuits: Class RK1, time-delay.
- C. Primary Protection for Control Transformers: Class CC, time-delay.

#### 2.03 FUSES

- A. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose indicated.
- B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.
- C. Provide fuses of the same type, rating, and manufacturer within the same switch.
- D. Comply with UL 248-1.
- E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.
- F. Voltage Rating: Suitable for circuit voltage.
- G. Class R Fuses: Comply with UL 248-12.
- H. Class CC Fuses: Comply with UL 248-4.
- I. Power Load Feeder Switches: Class RK1 (time delay).
- J. Motor Load Feeder Switches: Class RK1 (time delay).
- K. Other Feeder Switches: Class RK1 (time delay).
- L. General Purpose Branch Circuits: Class RK1 (time delay).
- M. Motor Branch Circuits: Class L time delay.
- N. Lighting Branch Circuits: Class G.

### 2.04 CLASS RK1 (TIME DELAY) FUSES

- A. Manufacturers:
  - 1. Bussman Corp.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- B. Construction: Current limiting, dual-element fuse, 10 seconds minimum at 500% rated amps, with copper fuse element.

#### PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify that fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.
- B. Verify that conditions are satisfactory for installation prior to starting work.

#### 3.02 INSTALLATION

- A. Do not install fuses until circuits are ready to be energized.
- B. Install fuses with label oriented such that manufacturer, type, and size are easily read.

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# SECTION 26 28 17 ENCLOSED CIRCUIT BREAKERS

#### PART 1 GENERAL

### 1.01 SECTION INCLUDES

A. Enclosed circuit breakers.

## 1.02 RELATED REQUIREMENTS

- A. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 Hangers and Supports for Electrical Systems.
- C. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- D. Section 26 05 73 Overcurrent Protective Device Coordination Study: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.

### 1.03 REFERENCE STANDARDS

- A. FS W-C-375 Circuit Breakers, Molded Case; Branch Circuit and Service; Federal Specification.
- B. NECA 1 Standard for Good Workmanship in Electrical Construction.
- C. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- D. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- E. NFPA 70 National Electrical Code.
- F. UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations.
- G. UL 50E Enclosures for Electrical Equipment, Environmental Considerations.
- H. UL 489 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
- I. UL 869A Reference Standard for Service Equipment.
- J. UL 943 Ground-Fault Circuit-Interrupters.
- K. UL 1053 Ground-Fault Sensing and Relaying Equipment.

### 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 4. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

#### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for circuit breakers, enclosures, and other installed components and accessories.

- C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
  - 1. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
  - 2. Include documentation of listed series ratings.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

#### **1.06 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Maintain one copy of each document on site.
- D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed circuit breaker internal components, enclosure, and finish.

#### 1.08 FIELD CONDITIONS

A. Maintain ambient temperature between 23 degrees F and 104 degrees F during and after installation of enclosed circuit breakers.

#### 1.09 EXTRA MATERIALS

A. See Section 01 6000 - Product Requirements, for additional provisions.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. Eaton Corporation; Cutler-Hammer Products: www.eaton.com.
- B. General Electric Company: www.geindustrial.com.
- C. Schneider Electric; Square D Products: www.schneider-electric.us.
- D. Substitutions: See Section 01 60 00 Product Requirements.
- E. Source Limitations: Furnish enclosed circuit breakers and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

### 2.02 ENCLOSED CIRCUIT BREAKERS

- A. Description: Units consisting of molded case circuit breakers individually mounted in enclosures.
- B. Provide products listed and labeled by Underwriters Laboratories Inc. as suitable for the purpose indicated.

- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
  - 1. Altitude: Less than 6,600 feet.
  - 2. Ambient Temperature: Between 23 degrees F and 104 degrees F.
- D. Short Circuit Current Rating:
  - 1. Provide enclosed circuit breakers with listed short circuit current rating not less than the available fault current at the installed location indicated on the drawings.
  - 2. Listed series ratings are acceptable, except where not permitted by motor contribution according to NFPA 70.
  - 3. Label equipment utilizing series ratings as required by NFPA 70.
- E. Enclosed Circuit Breakers Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- F. Conductor Terminations: Suitable for use with the conductors to be installed.
- G. Provide thermal magnetic circuit breakers unless otherwise indicated.
- H. Provide electronic trip circuit breakers where indicated.
- I. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- J. Provide solidly bonded equipment ground bus in each enclosed circuit breaker, with a suitable lug for terminating each equipment grounding conductor.
- K. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
    - b. Outdoor Locations: Type 3R.
  - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
  - 3. Provide surface-mounted enclosures unless otherwise indicated.
- L. Provide externally operable handle with means for locking in the OFF position.
- M. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
  - 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
  - 2. Where accessory ground fault sensing and relaying equipment is used, equip companion circuit breakers with ground-fault shunt trips.
    - a. Use zero sequence ground fault detection method unless otherwise indicated.
    - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.

## 2.03 MOLDED CASE CIRCUIT BREAKERS

- A. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
- B. Interrupting Capacity:
  - 1. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
    - a. 14000 min. rms symmetrical amperes at 240 VAC or 208 VAC.
    - b. 21000 min. rms symmetrical amperes at 480 VAC.
  - 2. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.

- 3. Series Rated Systems: Provide circuit breakers listed in combination with upstream devices to provide interrupting rating not less than the short circuit current rating indicated.
- C. Conductor Terminations:
  - 1. Provide mechanical lugs unless otherwise indicated.
  - 2. Lug Material: Copper, suitable for terminating copper conductors only.
- D. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
  - 1. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
  - 2. Provide interchangeable trip units for circuit breaker frame sizes 225 amperes and larger.
- E. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
  - 1. Provide the following field-adjustable trip response settings:
    - a. Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
    - b. Long time delay.
    - c. Short time pickup and delay.
    - d. Instantaneous pickup.
    - e. Ground fault pickup and delay where ground fault protection is indicated.
- F. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
- G. Provide the following circuit breaker types where indicated:
  - 1. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
- H. Provide listed switching duty rated circuit breakers with SWD marking for all branch circuits serving fluorescent lighting.
- I. Provide the following features and accessories where indicated or where required to complete installation:
  - 1. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
- J. Molded Case Circuit Breakers: UL listed for the following service conditions:
  - 1. Temperature: 95 degrees F.
  - 2. Altitude: 1000 feet.

#### 2.04 TRIP UNITS

- A. Field-Adjustable Trip Circuit Breakers: Provide circuit breakers with frame sizes 200 amperes and larger with mechanism for adjusting long time continuous current, short time pickup current setting for automatic operation. Range of Adjustment: amperes.
- B. Field-Changeable Ampere Rating Circuit Breaker: Provide circuit breakers with frame sizes 250 amperes and larger with changeable trip units.
- C. Current Limiting Circuit Breaker: Provide circuit breaker as indicated with automatically-resetting current limiting elements in each pole. Let-through Current and Energy: Less than permitted for same size Class RK-5 fuse.
- D. Solid-State Circuit Breaker: Provide circuit breaker as scheduled with electronic sensing, timing and tripping circuits for adjustable current settings; ground fault trip with zero sequence type ground fault sensor; instantaneous trip.

#### 2.05 CURRENT LIMITERS

- A. Current Limiters: Designed for application with molded case circuit breaker.
- B. Coordinate limiter size with trip rating of circuit breaker to prevent nuisance tripping and to achieve interrupting current rating specified for circuit breaker.

C. Provide interlocks to trip circuit breaker and to prevent closing circuit breaker when limiter compartment cover is removed or when one or more limiter is not in place or has operated.

### 2.06 ACCESSORIES

- A. Enclosures:
  - 1. Fabricate enclosures from steel.
  - 2. Finish: Manufacturer's standard enamel finish, gray color.
- B. Provide accessories as scheduled.
- C. Handle Lock: Include provisions for padlocking.
- D. Provide mechanical trip device.
- E. Provide grounding lug in each enclosure.
- F. Provide products suitable for use as service entrance equipment where so applied.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that the ratings of the enclosed circuit breakers are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed circuit breakers.
- D. Verify that conditions are satisfactory for installation prior to starting work.

## 3.02 INSTALLATION

- A. Install enclosed circuit breakers where indicated, in accordance with manufacturer's instructions.
- B. Install enclosed circuit breakers securely, in a neat and workmanlike manner in accordance with NECA 1.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required supports in accordance with Section 26 05 29.
- E. Install enclosed circuit breakers plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed circuit breakers such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 26 05 26.
- H. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- I. Height: 5 feet to operating handle.
- J. Provide identification nameplates for each enclosed circuit breaker in accordance with Section 26 0553.
- K. Provide arc flash warning labels in accordance with NFPA 70.

### 3.03 FIELD QUALITY CONTROL

- A. Perform inspection, testing, and adjusting in accordance with Section 01 40 00.
- B. Inspect and test in accordance with manufacturer's instructions and NETA STD ATS, except Section 4.

- C. Perform inspections and tests listed in NETA STD ATS, Section 7.6.1.1 for circuit breakers used for service entrance and for circuit breakers larger than 400 amperes. Tests listed as optional are not required.
- D. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- E. Test GFCI circuit breakers to verify proper operation.
- F. Test shunt trips to verify proper operation.
- G. Correct deficiencies and replace damaged or defective enclosed circuit breakers.
- H. Perform field inspection and testing in accordance with Section 01 4000.
- I. Inspect and test each circuit breaker.
- J. Inspect each circuit breaker visually.
- K. Perform several mechanical ON-OFF operations on each circuit breaker.
- L. Verify circuit continuity on each pole in closed position.
- M. Determine that circuit breaker will trip on overcurrent condition, with tripping time to NEMA AB 1 requirements.
- N. Include description of testing and results in test report.

### 3.04 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

### 3.05 CLEANING

- A. Clean dirt and debris from circuit breaker enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

# SECTION 26 28 18 ENCLOSED SWITCHES

### PART 1 GENERAL

### 1.01 SECTION INCLUDES

- A. Enclosed safety switches.
- B. Fusible switches.
- C. Nonfusible switches.

## 1.02 RELATED REQUIREMENTS

- A. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 Hangers and Supports for Electrical Systems.
- C. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- D. Section 26 05 73 Overcurrent Protective Device Coordination Study: Additional criteria for the selection of equipment and associated protective devices specified in this section.
- E. Section 26 28 13 Fuses.
- F. Section 26 29 13 Enclosed Controllers: Manual motor controllers.
- G. Section 26 36 00 Transfer Switches: Automatic and non-automatic switches listed for use as transfer switch equipment.

## 1.03 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction.
- B. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. NEMA FU 1 Low Voltage Cartridge Fuses; National Electrical Manufacturers Association.
- D. NEMA KS 1 Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
- E. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- F. NFPA 70 National Electrical Code.
- G. UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations.
- H. UL 50E Enclosures for Electrical Equipment, Environmental Considerations.
- I. UL 98 Enclosed and Dead-Front Switches.

## 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
- C. Project Record Documents: Record actual locations of enclosed switches.

### 1.05 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

## PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Eaton Corporation; Cutler-Hammer Products; Model : www.eaton.com.
- B. General Electric Company; Model : www.geindustrial.com.
- C. Schneider Electric; Square D Products; Model : www.schneider-electric.us.

- D. Substitutions: See Section 01 60 00 Product Requirements.
- E. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

## 2.02 ENCLOSED SAFETY SWITCHES

- A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
  - 1. Altitude: Less than 6,600 feet.
  - 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
- D. Horsepower Rating: Suitable for connected load.
- E. Voltage Rating: Suitable for circuit voltage.
- F. Short Circuit Current Rating:
- G. Provide with switch blade contact position that is visible when the cover is open.
- H. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
- I. Conductor Terminations: Suitable for use with the conductors to be installed.
- J. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- K. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
    - b. Outdoor Locations: Type 3R.
- L. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- M. Heavy Duty Switches:
  - 1. Products:
    - a. Schneider Electric.
    - b. General Electric Co.
    - c. Cutler Hammer.
    - d. Substitutions: See Section 01 60 00 Product Requirements.
  - 2. Comply with NEMA KS 1.
  - 3. Conductor Terminations:
    - a. Provide mechanical lugs unless otherwise indicated.
    - b. Provide compression lugs where indicated.
    - c. Lug Material: Copper, suitable for terminating copper conductors only.
  - 4. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.

### 2.03 COMPONENTS

- A. Fusible Switch Assemblies: NEMA KS 1, Type HD enclosed load interrupter knife switch.
  - 1. Externally operable handle interlocked to prevent opening front cover with switch in ON position.
  - 2. Handle lockable in OFF position.
  - 3. Fuse clips: Designed to accommodate NEMA FU1, Class R fuses.

- B. Nonfusible Switch Assemblies: NEMA KS 1, Type HD enclosed load interrupter knife switch.
  1. Externally operable handle interlocked to prevent opening front cover with switch in ON position.
  - 2. Handle lockable in OFF position.
- C. Enclosures: NEMA KS 1.
  - 1. Interior Dry Locations: Type 1.
  - 2. Exterior Locations: Type 3R.

## PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed safety switches.
- D. Verify that conditions are satisfactory for installation prior to starting work.

## 3.02 INSTALLATION

- A. Install enclosed switches in accordance with manufacturer's instructions.
- B. Install enclosed switches securely, in a neat and workmanlike manner in accordance with NECA
  1.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required supports in accordance with Section 26 05 29.
- E. Install enclosed switches plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 26 05 26.
- H. Provide fuses complying with Section 26 28 13 for fusible switches as indicated or as required by equipment manufacturer's recommendations.
- I. Provide identification nameplate for each enclosed switch in accordance with Section 26 0553.
- J. Provide arc flash warning labels in accordance with NFPA 70.
- K. Install fuses in fusible disconnect switches.
- L. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

### 3.03 FIELD QUALITY CONTROL

- A. Perform field inspection, testing, and adjusting in accordance with Section 01 40 00.
- B. Inspect and test in accordance with NETA STD ATS, except Section 4.
- C. Perform inspections and tests listed in NETA STD ATS, Section 7.5.1.1.
- D. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

### 3.04 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

### 3.05 CLEANING

- A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

# SECTION 26 29 13 ENCLOSED CONTROLLERS

#### PART 1 GENERAL

### 1.01 SECTION INCLUDES

- A. Magnetic motor controllers.
- B. Combination magnetic motor controllers and disconnects.

### 1.02 RELATED REQUIREMENTS

- A. Section 26 05 29 Hangers and Supports for Electrical Systems.
- B. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- C. Section 26 28 13 Fuses.

### 1.03 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction.
- B. NEMA ICS 2 Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts.
- C. NEMA ICS 5 Industrial Control and Systems: Control Circuit and Pilot Devices.
- D. NEMA ICS 6 Industrial Control and Systems: Enclosures.
- E. NEMA KS 1 Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
- F. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- G. NFPA 70 National Electrical Code.

### 1.04 SUBMITTALS

- A. See Section 01 33 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
- C. Test Reports: Indicate field test and inspection procedures and test results.
- D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Maintenance Data: Replacement parts list for controllers.

### 1.05 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience and with service facilities within 100 miles of Project.
- C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

# PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Eaton Corporation; Cutler-Hammer Product: www.eaton.com.
- B. General Electric Company: www.geindustrial.com.
- C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Substitutions: See Section 01 60 00 - Product Requirements.

## 2.02 AUTOMATIC CONTROLLERS

- A. Magnetic Motor Controllers: NEMA ICS 2, AC general-purpose Class A magnetic controller for induction motors rated in horsepower.
- B. Coil Operating Voltage: 120 volts, 60 Hertz.
- C. Overload Relays: NEMA ICS 2; bimetal.
- D. Enclosures: NEMA ICS 6, Type 1.

## 2.03 ACCESSORIES

- A. Auxiliary Contacts: NEMA ICS 2, 2 normally open contacts in addition to seal-in contact.
- B. Cover Mounted Pilot Devices: NEMA ICS 5, standard duty oiltight type.
- C. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.
- D. Indicating Lights: Transformer, LED type.
- E. Selector Switches: Rotary type.
- F. Relays: NEMA ICS 2.
- G. Control Power Transformers: 120 volt secondary, 50 VA minimum, in each motor starter. Provide fused primary, secondary, and bond unfused leg of secondary to enclosure.

### 2.04 DISCONNECTS

- A. Combination Controllers: Combine motor controllers with disconnects in common enclosure. Obtain IEC Class 2 coordinated component protection.
- B. Fusible Switch Assemblies: NEMA KS 1, enclosed knife switch with externally operable handle. Fuse clips: Designed to accommodate Class R fuses.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Install enclosed controllers where indicated, in accordance with manufacturer's instructions.
- B. Install securely, in a neat and workmanlike manner, as specified in NECA 1.
- C. Provide supports in accordance with Section 26 05 29.
- D. Height: 5 ft to operating handle.
- E. Provide fuses for fusible switches; refer to Section 26 28 13 for product requirements.
- F. Select and install overload heater elements in motor controllers to match installed motor characteristics.
- G. Identify enclosed controllers in accordance with Section 26 05 53.

### 3.02 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Section 01 45 00.
- B. Inspect and test in accordance with NETA STD ATS, except Section 4.
- C. Perform inspections and tests listed in NETA STD ATS, Section 7.16.1.

# SECTION 26 29 23 VARIABLE-FREQUENCY MOTOR CONTROLLERS

#### PART 1 GENERAL

#### 1.01 SECTION INCLUDES

A. Variable frequency controllers.

### 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Housekeeping pads.
- B. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- C. Section 26 28 13 Fuses.

### 1.03 REFERENCE STANDARDS

- A. NEMA ICS 7.1 Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems.
- B. NEMA ICS 7 Industrial Control and Systems: Adjustable-Speed Drives.
- C. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- D. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- E. NFPA 70 National Electrical Code.

### 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
- C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.
- D. Test Reports: Indicate field test and inspection procedures and test results.
- E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- F. Manufacturer's Field Reports: Indicate start-up inspection findings.
- G. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.
- H. Maintenance Data: NEMA ICS 7.1. Include routine preventive maintenance schedule.

#### 1.05 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience and with service facilities within 100 miles of Project.
- C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

#### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. ABB: www.ABB.com.
- B. Schneider Electric; Square D Products: www.schneider-electric.us.
- C. Danfoss: www.danfoss.us.
- D. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 DESCRIPTION

- A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.
  - 1. Employ pulse-width-modulated inverter system.
  - 2. Design for ability to operate controller with motor disconnected from output.
  - 3. Design to attempt five automatic restarts following fault condition before locking out and requiring manual restart.
- B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public.
- C. Finish: Manufacturer's standard enamel.

### 2.03 OPERATING REQUIREMENTS

- A. Rated Input Voltage: 480 volts, three phase, 60 Hertz.
- B. Motor Nameplate Voltage: 460 volts, three phase, 60 Hertz.
- C. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.
- D. Operating Ambient: 0 degrees C to 40 degrees C.
- E. Minimum Efficiency at Full Load: 85 percent.
- F. Time to Stop: 5 seconds.
- G. Volts Per Hertz Adjustment: Plus or minus 0 percent.
- H. Current Limit Adjustment: 60 to 110 percent of rated.
- I. Acceleration Rate Adjustment: 0.5 to 30 seconds.
- J. Deceleration Rate Adjustment: 1 to 30 seconds.
- K. Input Signal: 4 to 20 mA DC.

#### 2.04 COMPONENTS

- A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current.
- B. Status Indicators: Separate indicators for overcurrent, overvoltage, ground fault, overtemperature, and input power ON.
- C. Furnish HAND-OFF-AUTOMATIC selector switch and manual speed control.
- D. Include undervoltage release.

- E. Control Power Source: Integral control transformer.
- F. Door Interlocks: Furnish mechanical means to prevent opening of equipment with power connected, or to disconnect power if door is opened; include means for defeating interlock by qualified persons.
- G. Safety Interlocks: Furnish terminals for remote contact to inhibit starting under both manual and automatic mode.
- H. Control Interlocks: Furnish terminals for remote contact to allow starting in automatic mode.
- I. Manual Bypass: Furnish contactor, motor running overload protection, and short circuit protection for full voltage, non-reversing operation of the motor. Include isolation switch to allow maintenance of inverter during bypass operation.
- J. Emergency Stop: Use dynamic brakes for emergency stop function.
- K. Disconnecting Means: Include integral fused disconnect switch on the line side of each controller.
- L. Wiring Terminations: Match conductor materials and sizes indicated.
- M. Line Reactor: Furnish line reactor (s) for harmonics mitigation.

#### 2.05 SOURCE QUALITY CONTROL

- A. Shop inspect and perform standard productions tests for each controller.
- B. Make completed controller available for inspection at manufacturer's factory prior to packaging for shipment. Notify Caesar Rodney School District at least 7 days before inspection is allowed.

#### PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify that surface is suitable for controller installation.
- B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.
- C. Verify that field measurements are as indicated on shop drawings.

#### 3.02 INSTALLATION

- A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- B. Tighten accessible connections and mechanical fasteners after placing controller.
- C. Provide fuses in fusible switches; refer to Section 26 28 13 for product requirements.
- D. Select and install overload heater elements in motor controllers to match installed motor characteristics.
- E. Identify variable frequency controllers in accordance with Section 26 05 53.

#### 3.03 FIELD QUALITY CONTROL

- A. Provide the service of the manufacturer's field representative to prepare and start controllers.
- B. Perform field inspection and testing in accordance with Section 01 40 00.
- C. Inspect and test in accordance with NETA STD ATS, except Section 4.
- D. Perform inspections and tests listed in NETA STD ATS, Section 7.17.

### 3.04 ADJUSTING

A. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

### 3.05 CLOSEOUT ACTIVITIES

A. Demonstrate operation of controllers in automatic and manual modes.

#### 3.06 MAINTENANCE

- A. See Section 01 70 00 Execution Requirements, for additional requirements relating to maintenance service.
- B. Provide a separate maintenance contract for specified maintenance service.
- C. Provide service and maintenance of controllers for one year from Date of Substantial Completion.
# SECTION 26 32 13 ENGINE GENERATORS

### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Packaged engine generator system and associated components and accessories:
  - 1. Engine and engine accessory equipment.
  - 2. Alternator (generator).
  - 3. Generator set control system.
  - 4. Generator set enclosure.
- B. Packaged engine generator set.
- C. Heat exchanger.
- D. Exhaust silencer, emissions controls, and fittings.
- E. Remote control panel.
- F. Battery and charger.
- G. Sound enclosure.
- H. Portable Generator Loading Dock

### 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 22 10 05 Plumbing Piping: Gas piping.
- C. Section 23 31 00 HVAC Ducts and Casings.
- D. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- E. Section 26 05 29 Hangers and Supports for Electrical Systems.
- F. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- G. Section 26 36 00 Transfer Switches.

#### 1.03 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction.
- B. NECA/EGSA 404 Standard for Installing Generator Sets.
- C. NEMA MG 1 Motors and Generators.
- D. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association.
- E. NFPA 30 Flammable and Combustible Liquids Code.
- F. NFPA 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.
- G. NFPA 70 National Electrical Code.
- H. NFPA 99 Health Care Facilities Code.
- I. NFPA 110 Standard for Emergency and Standby Power Systems.
- J. UL 1236 Battery Chargers for Charging Engine-Starter Batteries.
- K. UL 2200 Stationary Engine Generator Assemblies.

# 1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

- 1. Coordinate compatibility of generator sets to be installed with work provided under other sections or by others.
  - a. Transfer Switches: See Section 26 36 00.
- 2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment or other potential obstructions within the spaces dedicated for engine generator system.
- 3. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
- 4. Coordinate the work to provide electrical circuits suitable for the power requirements of the actual auxiliary equipment and accessories to be installed.
- 5. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Preinstallation Meeting: Convene one week before starting work of this section; require attendance of all affected installers.

# 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features. Include alternator starting capabilities, engine fuel consumption rates, and cooling, combustion air, and exhaust requirements.
  - 1. Include generator set sound level test data.
  - 2. Include characteristic trip curves for overcurrent protective devices upon request.
  - 3. Include alternator thermal damage curve upon request.
- C. Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, and field connection locations. Include system interconnection schematic diagrams showing all factory and field connections.
- D. Specimen Warranty: Submit sample of manufacturer's warranty.
- E. Evidence of qualifications for installer.
- F. Evidence of qualifications for maintenance contractor (if different entity from installer).
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- H. Manufacturer's factory emissions certification.
- I. Manufacturer's certification that products meet or exceed specified requirements.
- J. Source quality control test reports.
- K. Provide NFPA 110 required documentation from manufacturer where requested by authorities having jurisdiction, including but not limited to:
  - 1. Certified prototype tests.
  - 2. Torsional vibration compatibility certification.
  - 3. NFPA 110 compliance certification.
  - 4. Certified rated load test at rated power factor.
- L. Manufacturer's detailed field testing procedures.
- M. Field quality control test reports.
- N. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.

- O. Executed Warranty: Submit documentation of final executed warranty completed in Caesar Rodney School District's name and registered with manufacturer.
- P. Maintenance contracts.
- Q. Project Record Documents: Record actual locations of system components, installed circuiting arrangements and routing, and final equipment settings.
- R. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
  - 2. Extra Fuses: One of each type and size.
  - 3. Extra Filter Elements: One of each type, including fuel, oil and air.
- S. Shop Drawings: Indicate electrical characteristics and connection requirements. Show plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, ventilation and combustion air requirements, electrical diagrams including schematic and interconnection diagrams.
- T. Product Data: Provide data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, day tank, and remote radiator.
- U. Test Reports: Indicate results of performance testing.
- V. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- W. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- X. Manufacturer's Field Reports: Indicate procedures and findings.
- Y. Operation Data: Include instructions for normal operation.
- Z. Maintenance Data: Include instructions for routine maintenance requirements, service manuals for engine and day tank, oil sampling and analysis for engine wear, and emergency maintenance procedures.
- AA. Maintenance Materials and Tools: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. Extra Filter Elements: One of each type, including fuel, oil and air.
  - 2. Tools: One set of tools required for preventative maintenance of the engine generator system. Package tools in adequately sized metal tool box.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with the following:
  - 1. NFPA 70 (National Electrical Code).
  - 2. NFPA 110 (Standard for Emergency and Standby Power Systems); meet requirements for Level 1 system.
  - 3. NFPA 37 (Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines).
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
  - 1. Authorized service facilities located within 200 miles of project site.

- D. Installer Qualifications: Company specializing in performing the work of this section with minimum three years documented experience with engine generator systems of similar size, type, and complexity; manufacturer's authorized installer.
- E. Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.

1. Contract maintenance office located within 200 miles of project site.

- F. Products: Listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authorities having jurisdiction as suitable for the purpose indicated.
- G. Conform to requirements of NFPA 70.
  - 1. Maintain one copy of each document on site.
- H. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience with service facilities within 100 miles of Project.
- I. Supplier Qualifications: Authorized distributor of specified manufacturer with minimum three years documented experience.
- J. Products: Furnish products listed and classified by Underwriters Laboratories as suitable for purpose specified and indicated.

# 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store generator sets in accordance with manufacturer's instructions and NECA/EGSA 404.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's instructions to avoid damage to generator set components, enclosure, and finish.

### 1.08 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

# 1.09 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.
- C. Accept unit on site on skids. Inspect for damage.
- D. Protect equipment from dirt and moisture by securely wrapping in heavy plastic.

# PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Packaged Engine Generator Set Basis of Design: Kohler Power Systems; Model 50 REZGB
- B. Packaged Engine Generator Set Other Acceptable Manufacturers:
  - 1. Caterpillar Inc: www.cat.com/power-generation.
  - 2. Cummins Power Generation Inc: www.cumminspower.com.
  - 3. Generac Power Systems: www.generac.com/industrial.
- C. Substitutions: See Section 01 60 00 Product Requirements.
- D. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts

responsibility for costs associated with any necessary modifications to related work, including any design fees.

- E. Source Limitations: Furnish engine generator sets and associated components and accessories produced by a single manufacturer and obtained from a single supplier.
- F. Caterpillar Inc: www.caterpillar.com.
- G. Cummins Engine Company, I: www.cummins.com.
- H. Kohler Power Systems: www.kohler.com.
- I. Substitutions: See Section 01 60 00 Product Requirements.

### 2.02 PACKAGED ENGINE GENERATOR SYSTEM

- A. Provide new engine generator system consisting of all required equipment, sensors, conduit, boxes, wiring, piping, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. System Description:
  - 1. Application: Stand by.
  - 2. Configuration: Single packaged engine generator set operated independently (not in parallel).
- D. Packaged Engine Generator Set:
  - 1. Type: Gaseous (spark ignition).
  - 2. Basis of Design: Kohler Power Systems Model 50 REZGB.
  - 3. Power Rating: As indicated on drawings, standby.
  - 4. Voltage: As indicated on drawings.
  - 5. Main Line Circuit Breaker:
    - a. Type: Thermal magnetic.
    - b. Trip Rating: Select according to generator set rating.
    - c. Features:
- E. Generator Set General Requirements:
  - 1. Prototype tested in accordance with NFPA 110 for Level 1 systems.
  - 2. Factory-assembled, with components mounted on suitable base.
  - 3. List and label engine generator assembly as complying with UL 2200.
  - 4. Power Factor: Unless otherwise indicated, specified power ratings are at 0.8 power factor for three phase voltages and 1.0 power factor for single phase voltages.
  - 5. Provide suitable guards to protect personnel from accidental contact with rotating parts, hot piping, and other potential sources of injury.
  - 6. Main Line Circuit Breakers: Provide factory-installed line side connections with suitable lugs for load side connections.
- F. Service Conditions: Provide engine generator system and associated components suitable for operation under the service conditions at the installed location.
  - 1. Altitude: 1000 feet.
  - 2. Ambient Temperature: Between 0 and 104 degrees F.
- G. Starting and Load Acceptance Requirements:
  - 1. Cranking Method: Cycle cranking complying with NFPA 110 (15 second crank period, followed by 15 second rest period, with cranking limiter time-out after 3 cycles), unless otherwise required.
  - 2. Cranking Limiter Time-Out: If generator set fails to start after specified cranking period, indicate overcrank alarm condition and lock-out generator set from further cranking until manually reset.

- 3. Start Time: Capable of starting and achieving conditions necessary for load acceptance within 10 seconds (NFPA 110, Type 10).
- 4. Maximum Load Step: Supports 100 percent of rated load in one step.
- H. Exhaust Emissions Requirements:
  - 1. Comply with federal (EPA), state, and local regulations applicable at the time of commissioning; include factory emissions certification with submittals.
  - 2. Do not make modifications affecting generator set factory emissions certification without approval of manufacturer and Engineer. Where such modifications are made, provide field emissions testing as necessary for certification.
- I. Sound Level Requirements:
  - 1. Do not exceed 69 dBA when measured at 23 feet from generator set in free field (no sound barriers) while operating at full load; include manufacturer's sound data with submittals.
- J. Description: NFPA 110, engine generator system to provide source of power for Level 1 applications conforming to NFPA 99.
- K. System Capacity: 50 kW, 63 kVA at elevation of 100 feet above sea level, continuous rating using engine-mounted radiator.

# 2.03 ENGINE AND ENGINE ACCESSORY EQUIPMENT

- A. Provide engine with adequate horsepower to achieve specified power output at rated speed, accounting for alternator efficiency and parasitic loads.
- B. Engine Fuel System Gaseous (Spark Ignition):
  - 1. Fuel Source: Natural gas.
  - 2. Engine Fuel Connections: Provide suitable, approved flexible fuel lines for coupling engine to fuel source.
  - 3. Provide components/features indicated and as necessary for operation and/or required by applicable codes, including but not limited to:
    - a. Carburetor.
    - b. Gas pressure regulators.
    - c. Fuel shutoff control valves.
    - d. Low gas pressure switches.
- C. Engine Starting System:
  - 1. System Type: Electric, with DC solenoid-activated starting motor(s).
  - 2. Battery(s):
    - a. Battery Type: Lead-acid.
    - b. Battery Capacity: Size according to manufacturer's recommendations for achieving starting and load acceptance requirements under worst case ambient temperature; capable of providing cranking through two complete periods of cranking limiter time-outs without recharging.
    - c. Provide battery rack, cables, and connectors suitable for the supplied battery(s); size battery cables according to manufacturer's recommendations for cable length to be installed.
  - 3. Battery-Charging Alternator: Engine-driven, with integral solid-state voltage regulation.
  - 4. Battery Charger:
    - a. Provide dual rate battery charger with automatic float and equalize charging modes and minimum rating of 10 amps; suitable for maintaining the supplied battery(s) at full charge without manual intervention.
    - b. Capable of returning supplied battery(s) from fully discharged to fully charged condition within 24 hours, as required by NFPA 110 for Level 1 applications while carrying normal loads.

- c. Recognized as complying with UL 1236.
- d. Furnished with integral overcurrent protection; current limited to protect charger during engine cranking; reverse polarity protection.
- e. Provide integral DC output ammeter and voltmeter with five percent accuracy.
- f. Provide alarm output contacts as necessary for alarm indications.
- 5. Battery Heater: Provide thermostatically controlled battery heater to improve starting under cold ambient conditions.
- D. Engine Speed Control System (Governor):
  - 1. Single Engine Generator Sets (Not Operated in Parallel): Provide electronic isochronous governor for controlling engine speed/alternator frequency.
  - 2. Frequency Regulation, Electronic Isochronous Governors: No change in frequency from no load to full load; plus/minus 0.25 percent at steady state.
- E. Engine Lubrication System:
  - 1. System Type: Full pressure, with engine-driven, positive displacement lubrication oil pump, replaceable full-flow oil filter(s), and dip-stick for oil level indication. Provide oil cooler where recommended by manufacturer.
  - 2. Oil Heater: Provide thermostatically controlled oil heater to improve starting under cold ambient conditions.
- F. Engine Cooling System:
  - 1. System Type: Closed-loop, liquid-cooled, with unit-mounted radiator/fan and engine-driven coolant pump; suitable for providing adequate cooling while operating at full load under worst case ambient temperature.
  - 2. Fan Guard: Provide suitable guard to protect personnel from accidental contact with fan.
- G. Engine Air Intake and Exhaust System:
  - 1. Air Intake Filtration: Provide engine-mounted, replaceable, dry element filter.
  - 2. Engine Exhaust Connection: Provide suitable, approved flexible connector for coupling engine to exhaust system.
  - 3. Exhaust Silencer: Provide critical grade or better exhaust silencer with sound attenuation not less than basis of design; select according to manufacturer's recommendations to meet sound performance requirements, where specified.
- H. Type: Water-cooled inline or V-type, four stroke cycle, electric ignition natural-gas internal combustion engine.
- I. Rating: Sufficient to operate under 10 percent overload for one hour in an ambient of 90 degrees F at elevation of 1000 feet.
- J. Fuel System: Natural gas. Include manufacturer's approved regulator for pressure reduction from supply pressure.
- K. Engine speed: 1800 rpm.
- L. Governor: Isochronous type to maintain engine speed within 0.5 percent, steady state, and 5 percent, no load to full load, with recovery to steady state within 2 seconds following sudden load changes. Equip governor with means for manual operation and adjustment.
- M. Safety Devices: Engine shutdown on high water temperature, low oil pressure, overspeed, and engine overcrank. Limits as selected by manufacturer.
- N. Engine Starting: DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Include remote starting control circuit, with MANUAL-OFF-REMOTE selector switch on engine-generator control panel.
- O. Engine Jacket Heater: Thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90 degrees F, and suitable for operation on 120 volts AC.

- P. Radiator: Radiator using glycol coolant, with blower type fan, sized to maintain safe engine temperature in ambient temperature of 110 degrees F. Radiator air flow restriction 0.5 inches of water maximum.
- Q. Engine Accessories: Fuel filter, lube oil filter, intake air filter, lube oil cooler, fuel transfer pump, fuel priming pump, gear-driven water pump. Include fuel pressure gage, water temperature gage, and lube oil pressure gage on engine/generator control panel.
- R. Mounting: Provide unit with suitable spring-type vibration isolators and mount on structural steel base.

# 2.04 ALTERNATOR (GENERATOR)

- A. Alternator: 4-pole, 1800 rpm (60 Hz output) revolving field, synchronous generator complying with NEMA MG 1; connected to engine with flexible coupling; voltage output configuration as indicated, with reconnectable leads for 3 phase alternators.
- B. Exciter:
  - 1. Exciter Type: Brushless; provide permanent magnet generator (PMG) excitation system; self-excited (shunt) systems are not permitted.
  - 2. PMG Excitation Short-Circuit Current Support: Capable of sustaining 300 percent of rated output current for 10 seconds.
  - 3. Voltage Regulation (with PMG excitation): Plus/minus 0.5 percent for any constant load from no load to full load.
- C. Temperature Rise: Comply with UL 2200.
- D. Insulation System: NEMA MG 1, Class H; suitable for alternator temperature rise.
- E. Enclosure: NEMA MG 1, drip-proof.
- F. Total Harmonic Distortion: Not greater than five percent.
- G. Alternator Heater: Provide strip heater to prevent moisture condensation on alternator windings.

#### 2.05 GENERATOR SET CONTROL SYSTEM

- A. Provide microprocessor-based control system for automatic control, monitoring, and protection of generator set. Include sensors, wiring, and connections necessary for functions/indications specified.
- B. Control Panel:
  - 1. Control Panel Mounting: Unit-mounted unless otherwise indicated; vibration isolated.
  - 2. Generator Set Control Functions:
    - a. Automatic Mode: Initiates generator set start/shutdown upon receiving corresponding signal from remote device (e.g. automatic transfer switch).
    - b. Manual Mode: Initiates generator set start/shutdown upon direction from operator.
    - c. Reset Mode: Clears all faults, allowing generator set restart after a shutdown.
    - d. Emergency Stop: Immediately shuts down generator set (without time delay) and prevents automatic restarting until manually reset.
    - e. Cycle Cranking: Programmable crank time, rest time, and number of cycles.
    - f. Time Delay: Programmable for shutdown (engine cooldown) and start (engine warmup).
    - g. Voltage Adjustment: Adjustable through range of plus/minus 5 percent.
  - 3. Generator Set Status Indications:
    - a. Voltage (Volts AC): Line-to-line, line-to-neutral for each phase.
    - b. Current (Amps): For each phase.
    - c. Frequency (Hz).
    - d. Real power (W/kW).
    - e. Reactive power (VAR/kVAR).

- f. Apparent power (VA/kVA).
- g. Power factor.
- h. Duty Level: Actual load as percentage of rated power.
- i. Engine speed (RPM).
- j. Battery voltage (Volts DC).
- k. Engine oil pressure.
- I. Engine coolant temperature.
- m. Engine run time.
- n. Generator powering load (position signal from transfer switch).
- 4. Generator Set Protection and Warning/Shutdown Indications:
  - a. Comply with NFPA 110; configurable for NFPA 110 Level 1 or Level 2, or NFPA 99 systems including but not limited to the following protections/indications:
    - 1) Overcrank (shutdown).
    - 2) Low coolant temperature (warning).
    - 3) High coolant temperature (warning).
    - 4) High coolant temperature (shutdown).
    - 5) Low oil pressure (shutdown).
    - 6) Overspeed (shutdown).
    - 7) Low fuel level (warning).
    - 8) Low coolant level (warning/shutdown).
    - 9) Generator control not in automatic mode (warning).
    - 10) High battery voltage (warning).
    - 11) Low cranking voltage (warning).
    - 12) Low battery voltage (warning).
    - 13) Battery charger failure (warning).
  - b. In addition to NFPA 110 requirements, provide the following protections/indications:
    - 1) High AC voltage (shutdown).
    - 2) Low AC voltage (shutdown).
    - 3) High frequency (shutdown).
    - 4) Low frequency (shutdown).
    - 5) Overcurrent (shutdown).
  - c. Provide contacts for local and remote common alarm.
  - d. Provide lamp test function that illuminates all indicator lamps.
- 5. Other Control Panel Features:
  - a. Event log.
  - b. Communications Capability: Compatible with system indicated. Provide all accessories necessary for proper interface.
  - c. Remote monitoring capability via PC.
- C. Remote Annunciator:
  - 1. Remote Annunciator Mounting: Wall-mounted; Provide flush-mounted annunciator for finished areas and surface-mounted annunciator for non-finished areas unless otherwise indicated.
  - 2. Generator Set Status Indications:
    - a. Generator powering load (via position signal from transfer switch).
    - b. Communication functional.
  - 3. Generator Set Warning/Shutdown Indications:
    - a. Comply with NFPA 110 for Level 1 systems including but not limited to the following indications:
      - 1) Overcrank (shutdown).
      - 2) Low coolant temperature (warning).
      - 3) High coolant temperature (warning).

- 4) High coolant temperature (shutdown).
- 5) Low oil pressure (shutdown).
- 6) Overspeed (shutdown).
- 7) Low fuel level (warning).
- 8) Low coolant level (warning/shutdown).
- 9) Generator control not in automatic mode (warning).
- 10) High battery voltage (warning).
- 11) Low cranking voltage (warning).
- 12) Low battery voltage (warning).
- 13) Battery charger failure (warning).
- b. Provide audible alarm with silence function.
- c. Provide lamp test function that illuminates all indicator lamps.
- D. Remote Emergency Stop: Provide approved red, mushroom style remote emergency stop button where indicated or required by authorities having jurisdiction.

## 2.06 GENERATOR SET ENCLOSURE

- A. Enclosure Type: Sound attenuating, weather protective.
- B. Enclosure Material: Steel.
- C. Hardware Material: Stainless steel.
- D. Color: Manufacturer's standard.
- E. Access Doors: Lockable, with all locks keyed alike.
- F. Openings: Designed to prevent bird/rodent entry.
- G. External Drains: Extend oil and coolant drain lines to exterior of enclosure for maintenance service.
- H. Sound Attenuating Enclosures: Line enclosure with non-hydroscopic, self-extinguishing sound-attenuating material.
- I. Exhaust Silencers: Where exhaust silencers are mounted within enclosure in main engine compartment, insulate silencer to minimize heat dissipation as necessary for operation at rated load under worst case ambient temperature.
- J. Enclosure Space Heater: Provide thermostatically controlled enclosure space heater to prevent condensation and improve starting under cold ambient conditions; size according to manufacturer's recommendations for achieving starting and load acceptance requirements under worst case ambient temperature.

#### 2.07 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Perform production tests on generator sets at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.
- C. Generator Set production testing to include, at a minimum:
  - 1. Operation at rated load and rated power factor.
    - 2. Single step load pick-up.
    - 3. Transient and steady state voltage and frequency performance.
  - 4. Operation of safety shutdowns.
- D. Generator: NEMA MG 1, three phase, four pole, reconnectable brushless synchronous generator with brushless exciter.
- E. Rating: 50 kW, 63 kVA, at 0.8 power factor, 480Y-277 volts, 60 Hz at 1800 rpm.
- F. Insulation Class: F.

- G. Temperature Rise: 130 degrees C Standby.
- H. Enclosure: NEMA MG 1, open drip proof.
- I. Voltage Regulation: Include generator-mounted volts per hertz exciter-regulator to match engine and generator characteristics, with voltage regulation plus or minus 1 percent from no load to full load. Include manual controls to adjust voltage droop, voltage level (plus or minus 5 percent) and voltage gain.

#### 2.08 ACCESSORIES

- A. Heat Exchanger: Engine or base-mounted heat exchanger and expansion tank of type and capacity recommended by engine manufacturer. Include solenoid shut-off valve for installation on the cooling water inlet, and connected to open when engine runs.
- B. Exhaust Silencer: Residential type silencer, with muffler companion flanges and flexible stainless steel exhaust fitting, sized in accordance with engine manufacturer's instructions.
- C. Batteries: Heavy duty, diesel starting type lead-acid storage batteries, 170 ampere-hours minimum capacity. Match battery voltage to starting system. Include necessary cables and clamps.
- D. Battery Tray: Treated for electrolyte resistance, constructed to contain spillage.
- E. Battery Charger: Current limiting type designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave rectifier, DC voltmeter and ammeter, and 120 volts AC fused input. Provide wall-mounted enclosure to meet NEMA 250, Type 1 requirements.
- F. Line Circuit Breaker: Molded case circuit breaker on generator output with integral thermal and instantaneous magnetic trip in each pole, sized in accordance with NFPA 70; UL listed. Include battery-voltage operated shunt trip, connected to open circuit breaker on engine failure. Unit mount in enclosure to meet NEMA 250, Type 1 requirements.
- G. Engine-Generator Control Panel: NEMA 250, Type 1 generator mounted control panel enclosure with engine and generator controls and indicators. Include provision for padlock and the following equipment and features:
  - 1. Frequency Meter: 45-65 Hz. range, 3.5 inch dial.
  - 2. AC Output Voltmeter: 3.5 inch dial, 2 percent accuracy, with phase selector switch.
  - 3. AC Output Ammeter: 3.5 inch dial, 2 percent accuracy, with phase selector switch.
  - 4. Output voltage adjustment.
  - 5. Push-to-test indicator lamps, one each for low oil pressure, high water temperature, overspeed, and overcrank.
  - 6. Engine start/stop selector switch.
  - 7. Engine running time meter.
  - 8. Oil pressure gage.
  - 9. Water temperature gage.
  - 10. Auxiliary Relay: 3PDT, operates when engine runs, with contact terminals prewired to terminal strip.
  - 11. Additional visual indicators and alarms as required by NFPA 110.
  - 12. Remote Alarm Contacts: Pre-wire SPDT contacts to terminal strip for remote alarm functions required by NFPA 110.
- H. Remote Annunciator Panel: Surface mounted panel with brushed stainless steel. Provide audible and visible indicators and alarms required by NFPA 110.
- I. Emissions controls: Catalyst based, meeting State of Delaware Department of Natural Resourcese and Environmental Controls standards for stand-by generators.

J. Sound Enclosure:Lift based steel construction with hinged doors,.Accoustic insulation meeting UL94HF1 flammibility classification and repels moisture absorbption. Maximium sound level shall be 69 dB at 23.1 ft.

# 2.09 PORTABLE GENERATOR LOADING DOCK:

- A. Construction:Pad mounted, NEMA 3R ,pad lockable enclosure. Enclosure shall be min. 12 gauge aluminum, painted with ANSI 61 gray color.
- B. Busbars: Silverplated copper busbars with ampacity as shown on drawings.
- C. Receptacles: (16) female color coded receptacles and provision for grounding
- D. Accessories: Phase rotation indicator, hinged bottom door.
- E. Manufacturer: Trystar, Penn Panel or approved equal.

# PART 3 EXECUTION

# 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that the ratings and configurations of generator sets and auxiliary equipment are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.
- D. Verify that mounting surfaces are ready to receive equipment.
- E. Verify that conditions are satisfactory for installation prior to starting work.

# 3.02 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1.
- B. Install products in accordance with manufacturer's instructions.
- C. Install generator sets and associated accessories in accordance with NECA/EGSA 404.
- D. Arrange equipment to provide minimum clearances and required maintenance access.
- E. Unless otherwise indicated, mount generator set on properly sized 6 inch high concrete pad constructed in accordance with Section 03 30 00. Provide suitable vibration isolators, where not factory installed.
- F. Provide required support and attachment in accordance with Section 26 05 29.
- G. Use manufacturer's recommended oil and coolant, suitable for the worst case ambient temperatures.
- H. Provide gas piping in accordance with Section 22 10 05.
- I. Provide engine exhaust piping in accordance with Section 23 51 00, where not factory installed.
  - 1. Include piping expansion joints, piping insulation, thimble, condensation trap/drain, rain cap, hangers/supports, etc. as indicated or as required.
  - 2. Do not exceed manufacturer's maximum back pressure requirements.
- J. Install exhaust silencer in accordance with Section 23 51 00, where not factory installed.
- K. Provide grounding and bonding in accordance with Section 26 05 26.
- L. Identify system wiring and components in accordance with Section 26 05 53.
- M. All incoming feeders shall enter from bottom of portable generator connection box and conduits shall exit from sides only.

# 3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

- B. Provide services of a manufacturer's authorized representative to prepare and start systems and perform inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- C. Notify Caesar Rodney School District and StudioJAED at least two weeks prior to scheduled inspections and tests.
- D. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- E. Provide all equipment, tools, and supplies required to accomplish inspection and testing, including load bank and fuel.
- F. Preliminary inspection and testing to include, at a minimum:
  - 1. Inspect each system component for damage and defects.
  - 2. Verify tightness of mechanical and electrical connections are according to manufacturer's recommended torque settings.
  - 3. Check for proper oil and coolant levels.
- G. Prepare and start system in accordance with manufacturer's instructions.
- H. Perform acceptance test in accordance with NFPA 110.
- I. Inspection and testing to include, at a minimum:
  - 1. Verify compliance with starting and load acceptance requirements.
  - 2. Verify voltage and frequency; make required adjustments as necessary.
  - 3. Verify phase sequence.
  - 4. Verify control system operation, including safety shutdowns.
  - 5. Verify operation of auxiliary equipment and accessories (e.g. battery charger, heaters, etc.).
- J. Provide field emissions testing where necessary for certification.
- K. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.
- L. Submit detailed reports indicating inspection and testing results and corrective actions taken.
- M. Provide the services of manufacturer's representative to prepare and start system.
- N. Perform field inspection and testing in accordance with Section 01 4000.
- O. Provide full load test utilizing portable test bank, if required, for four hours minimum. Simulate power failure including operation of transfer switch, automatic starting cycle, and automatic shutdown and return to normal.
- P. Record in 20 minute intervals during four hour test:
  - 1. Kilowatts.
  - 2. Amperes.
  - 3. Voltage.
  - 4. Coolant temperature.
  - 5. Room temperature.
  - 6. Frequency.
  - 7. Oil pressure.
- Q. Test alarm and shutdown circuits by simulating conditions.
- R. Field-verify emissions levels to meet manufacturer's documented criteria per submittals.

# 3.04 ADJUSTING

A. Adjust generator output voltage and engine speed.

## 3.05 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

# 3.06 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of system to Caesar Rodney School District, and correct deficiencies or make adjustments as directed.
- C. Training: Train Caesar Rodney School District's personnel on operation, adjustment, and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of four hours of training.
  - 3. Instructor: Manufacturer's authorized representative.
  - 4. Location: At project site.

### 3.07 PROTECTION

- A. Protect installed engine generator system from subsequent construction operations.
- B. Demonstrate operation to Caesar Rodney School District's operating personnel:
  - 1. Describe loads connected to emergency system and restrictions for future load additions.
  - 2. Simulate power outage by interrupting normal source, and demonstrate that system operates to provide emergency power.

# 3.08 MAINTENANCE

- A. Provide to Caesar Rodney School District a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of engine generator system for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with a detailed schedule.
- B. Provide trouble call-back service upon notification by Caesar Rodney School District:
  - 1. Provide on-site response within 4 hours of notification.
  - 2. Include allowance for call-back service during normal working hours at no extra cost to Caesar Rodney School District.
  - 3. Caesar Rodney School District will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- C. Maintain an on-site log listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced.
- D. Provide a separate maintenance contract for specified maintenance service.
- E. Provide service and maintenance of engine generator for one year from Date of Substantial Completion.

# END OF SECTION

# SECTION 26 36 00 TRANSFER SWITCHES

#### PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Transfer switches for low-voltage (600 V and less) applications and associated accessories:
  - 1. Automatic transfer switches.
  - 2. Manual transfer switches.
  - 3. Includes service entrance rated transfer switches.
  - 4. Remote annunciators.
- B. Manual Transfer Switch.

# 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 Hangers and Supports for Electrical Systems.
- D. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 28 18 Enclosed Switches: Safety switches not listed for use as transfer switch equipment.
- F. Section 26 32 13 Engine Generators: For interface with transfer switches.
  - 1. Includes code requirements applicable to work of this section.
  - 2. Includes additional testing requirements.
- G. Section Engine Generators: Testing requirements.

### 1.03 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction.
- B. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. NEMA ICS 10 Part 1 Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment.
- D. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- E. NFPA 70 National Electrical Code.
- F. NFPA 110 Standard for Emergency and Standby Power Systems.
- G. UL 869A Reference Standard for Service Equipment.
- H. UL 1008 Transfer Switch Equipment.

# 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate compatibility of transfer switches to be installed with work provided under other sections or by others.
  - 2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
  - 3. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 4. Coordinate the work with placement of supports, anchors, etc. required for mounting.
  - 5. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

- B. Preinstallation Meeting: Convene one week before starting work of this section; require attendance of all affected installers.
- C. Where work of this section involves interruption of existing electrical service, arrange service interruption with Caesar Rodney School District.

## 1.05 SUBMITTALS

- A. See Section 01 3000 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features.
  - 1. Where applicable, include characteristic trip curves for overcurrent protective devices upon request.
- C. Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, and field connection locations. Include system interconnection schematic diagrams showing all factory and field connections.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- E. Manufacturer's certification that products meet or exceed specified requirements.
- F. Source quality control test reports.
- G. Manufacturer's detailed field testing procedures.
- H. Field quality control test reports.
- I. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- J. Executed Warranty: Submit documentation of final executed warranty completed in Caesar Rodney School District's name and registered with manufacturer.
- K. Maintenance contracts.
- L. Project Record Documents: Record actual locations of system components, installed circuiting arrangements and routing, and final equipment settings.
- M. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
- N. Product Data: Provide catalog sheets showing voltage, switch size, ratings and size of switching and overcurrent protective devices, operating logic, short circuit ratings, dimensions, and enclosure details.
- O. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- P. Operation Data: Instructions for operating equipment under emergency conditions when engine generator is running.
- Q. Maintenance Data: Routine preventative maintenance and lubrication schedule. List special tools, maintenance materials, and replacement parts.

### 1.06 QUALITY ASSURANCE

- A. Comply with the following:
  - 1. NFPA 70 (National Electrical Code).
  - 2. NFPA 110 (Standard for Emergency and Standby Power Systems); meet requirements for system Level specified in Section 26 32 13.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
  - 1. Authorized service facilities located within 200 miles of project site.
- D. Installer Qualifications: Company specializing in performing the work of this section with minimum three years documented experience with power transfer systems of similar size, type, and complexity; manufacturer's authorized installer.
- E. Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.
- F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- G. Conform to requirements of NFPA 70.
- H. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience and with service facilities within 100 miles of Project.
- I. Supplier Qualifications: Authorized distributor of specified manufacturer with minimum three years documented experience.
- J. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store transfer switches in accordance with manufacturer's instructions.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's instructions to avoid damage to transfer switch components, enclosure, and finish.

#### **1.08 FIELD CONDITIONS**

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

# 1.09 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

# PART 2 PRODUCTS

# 2.01 MANUFACTURERS

- A. Transfer Switches Basis of Design: ASCO power technologies 300 series..
- B. Eaton Corporation; Cutler-Hammer Products: www.eaton.com.

- C. Substitutions: See Section 01 60 00 Product Requirements.
- D. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.
- E. Source Limitations: Furnish transfer switches and accessories produced by a single manufacturer and obtained from a single supplier.

#### 2.02 TRANSFER SWITCHES

- A. Provide complete power transfer system consisting of all required equipment, conduit, boxes, wiring, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Applications:
  1. Utilize open transition transfer unless otherwise indicated or required.
- D. Construction Type: Either "contactor type" (open contact) or "breaker type" (enclosed contact) transfer switches complying with specified requirements are acceptable.
- E. Automatic Transfer Switch:1. Basis of Design: ASCO transfer swithces 300 series, .
- F. Comply with NEMA ICS 10 Part 1, and list and label as complying with UL 1008 for the classification of the intended application (e.g. emergency, optional standby).
- G. Do not use double throw safety switches or other equipment not specifically designed for power transfer applications and listed as transfer switch equipment.
- H. Load Classification: Classified for total system load (any combination of motor, electric discharge lamp, resistive, and tungsten lamp loads with tungsten lamp loads not exceeding 30 percent of the continuous current rating) unless otherwise indicated or required.
- I. Switching Methods:
  - 1. Open Transition:
    - a. Provide break-before-make transfer without a neutral position that is not connected to either source, and with interlocks to prevent simultaneous connection of the load to both sources.
  - 2. Obtain control power for transfer operation from line side of source to which the load is to be transferred.
- J. Service Conditions: Provide transfer switches suitable for continuous operation at indicated ratings under the service conditions at the installed location.
  - 1. Altitude: 1000 feet.
  - 2. Ambient Temperature: Between 0 degrees F and 104 degrees F.
- K. Enclosures:
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1 or Type 12.
    - b. Outdoor Locations: Type 3R or Type 4.
  - 2. Provide lockable door(s) for outdoor locations.
  - 3. Finish: Manufacturer's standard unless otherwise indicated.
- L. Short Circuit Current Rating:
- M. Automatic Transfer Switches:
  - 1. Description: Transfer switches with automatically initiated transfer between sources; electrically operated and mechanically held.

- 2. Control Functions:
  - a. Automatic mode.
  - b. Test Mode: Simulates failure of primary/normal source.
  - c. Voltage and Frequency Sensing:
    - 1) Undervoltage sensing for each phase of primary/normal source; adjustable dropout/pickup settings.
    - 2) Undervoltage sensing for alternate/emergency source; adjustable dropout/pickup settings.
    - 3) Underfrequency sensing for alternate/emergency source; adjustable dropout/pickup settings.
  - d. Outputs:
    - 1) Contacts for engine start/shutdown (except where direct generator communication interface is provided).
    - 2) Auxiliary contacts; one set(s) for each switch position.
  - e. Adjustable Time Delays:
    - 1) Engine generator start time delay; delays engine start signal to override momentary primary/normal source failures.
    - 2) Transfer to alternate/emergency source time delay.
    - 3) Retransfer to primary/normal source time delay.
    - 4) Engine generator cooldown time delay; delays engine shutdown following retransfer to primary/normal source to permit generator to run unloaded for cooldown period.
  - f. In-Phase Monitor (Open Transition Transfer Switches): Monitors phase angle difference between sources for initiating in-phase transfer.
  - g. Engine Exerciser: Provides programmable scheduled exercising of engine generator selectable with or without transfer to load; provides memory retention during power outage.
- 3. Status Indications:
  - a. Connected to alternate/emergency source.
  - b. Connected to primary/normal source.
  - c. Alternate/emergency source available.
- 4. Automatic Sequence of Operations:
  - a. Upon failure of primary/normal source for a programmable time period (engine generator start time delay), initiate starting of engine generator where applicable.
  - b. When alternate/emergency source is available, transfer load to alternate/emergency source after programmable time delay.
  - c. When primary/normal source has been restored, retransfer to primary/normal source after a programmable time delay. Bypass time delay if alternate/emergency source fails and primary/normal source is available.
  - d. Where applicable, initiate shutdown of engine generator after programmable engine cooldown time delay.
- N. Manual Transfer Switches:
  - 1. Description: Transfer switches with manually initiated transfer between sources; mechanically operated and mechanically held.
- O. Service Entrance Rated Transfer Switches:
  - 1. Furnished with integral disconnecting and overcurrent protective device on the primary/normal source and with ground-fault protection where indicated.
  - 2. Listed and labeled as suitable for use as service equipment according to UL 869A.
- P. Remote Annunciators:

- 1. Remote Annunciator Mounting: Wall-mounted; Provide flush-mounted annunciator for finished areas and surface-mounted annunciator for non-finished areas unless otherwise indicated.
- 2. Transfer Switch Status Indications:
  - a. Connected to alternate/emergency source.
  - b. Connected to primary/normal source.
  - c. Alternate/emergency source available.
  - d. Primary/normal source available.
- Q. Interface with Other Work:
  - 1. Interface with engine generators as specified in Section 26 32 13.
  - 2.

### 2.03 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Perform production tests on transfer switches at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.

#### 2.04 AUTOMATIC TRANSFER SWITCH

- A. Description: NEMA ICS 10, automatic transfer switch 400 amp,3 pole, in NEMA1 enclosure.
- B. Configuration: Electrically operated, mechanically held transfer switch.
- C. Interrupting Capacity: 42000 amp minimum ,rms .

#### 2.05 MANUAL TRANSFER SWITCH

- A. Description: NEMA ICS 10, manual transfer switch suitable for use as service equipment.
- B. Configuration: Manual transfer switch.

## 2.06 SERVICE CONDITIONS

- A. Service Conditions: NEMA ICS 10.
- B. Temperature: 105 deg F.
- C. Altitude: 3,300 feet.

#### 2.07 COMPONENTS

- A. Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE.
- B. Test Switch: Mount in cover of enclosure to simulate failure of normal source.
- C. Return to Normal Switch: Mount in cover of enclosure to initiate manual transfer from alternate source to normal source.
- D. Transfer Switch Auxiliary Contacts: 1 normally open; 1 normally closed.
- E. Normal Source Monitor: Monitor each line of normal source voltage and frequency; initiate transfer when voltage drops below 85 percent or frequency varies more than 3 percent from rated nominal value.
- F. Alternate Source Monitor: Monitor alternate source voltage and frequency; inhibit transfer when voltage is below 85 percent or frequency varies more than 3 percent from rated nominal value.
- G. In-Phase Monitor: Inhibit transfer until source and load are within zero electrical degrees.
- H. Switched Neutral: Overlapping contacts.
- I. Enclosure: ICS 10, Type 1, finished with manufacturer's standard gray enamel.

#### 2.08 AUTOMATIC SEQUENCE OF OPERATION

A. Initiate Time Delay to Start Alternate Source Engine Generator: Upon initiation by normal source monitor.

- B. Time Delay To Start Alternate Source Engine Generator: 0 to 6 seconds, adjustable.
- C. Initiate Transfer Load to Alternate Source: Upon initiation by normal source monitor and permission by alternate source monitor.
- D. Time Delay Before Transfer to Alternate Power Source: 0 to 60 seconds, adjustable.
- E. Initiate Retransfer Load to Normal Source: Upon permission by normal source monitor.
- F. Time Delay Before Transfer to Normal Power: 0 to 60 seconds, adjustable; bypass time delay in event of alternate source failure.
- G. Time Delay Before Engine Shut Down: 0 to 1 minutes, adjustable, of unloaded operation.
- H. Engine Exerciser: Start engine every 15days run for 30 minutes before shutting down. Bypass exerciser control if normal source fails during exercising period.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that the ratings and configurations of transfer switches are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.
- D. Verify that surface is suitable for transfer switch installation.

### 3.02 PREPARATION

A. Provide 6" housekeeping pads.

#### 3.03 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1.
- B. Install in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Install transfer switches plumb and level.
- E. Unless otherwise indicated, mount floor-mounted transfer switches on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00.
- F. Provide grounding and bonding in accordance with Section 26 05 26.
- G. Identify transfer switches in accordance with Section 26 05 53.
- H. Provide engraved plastic nameplates under the provisions of Section 26 0553.

#### 3.04 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- C. Prepare and start system in accordance with manufacturer's instructions.
- D. Automatic Transfer Switches:
  - 1. Inspect and test in accordance with NETA ATS, except Section 4.
  - 2. Perform inspections and tests listed in NETA ATS, Section 7.22.3. The control wiring insulation-resistance tests listed as optional are not required.
    - a. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.

- E. Provide additional inspection and testing as required for completion of associated engine generator testing as specified in Section 26 32 13.
- F. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.
- G. Submit detailed reports indicating inspection and testing results and corrective actions taken.
- H. Provide the services of the manufacturer's technical representative to check out transfer switch connections and operation and place in service.
- I. Perform field inspection and testing in accordance with Section .
- J. Inspect and test in accordance with NETA STD ATS, except Section 4.
- K. Perform inspections and tests listed in NETA STD ATS, Section 7.22.3.

### 3.05 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

# 3.06 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of transfer switches to Caesar Rodney School District, and correct deficiencies or make adjustments as directed.
- D. Training: Train Caesar Rodney School District's personnel on operation, adjustment, and maintenance of transfer switches.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
- E. Demonstrate operation of transfer switch in bypass, normal, and emergency modes.

## 3.07 PROTECTION

A. Protect installed transfer switches from subsequent construction operations.

#### 3.08 MAINTENANCE

- A. See Section 01 70 00 Execution Requirements, for additional requirements relating to maintenance service.
- B. Provide to Caesar Rodney School District a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of transfer switches for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with a detailed schedule.
- C. Conduct site visit at least once every three months to perform inspection, testing, and preventive maintenance. Submit report to Caesar Rodney School District indicating maintenance performed along with evaluations and recommendations.
- D. Provide trouble call-back service upon notification by Caesar Rodney School District:
  - 1. Provide on-site response within 4 hours of notification.
  - 2. Include allowance for call-back service during normal working hours at no extra cost to Caesar Rodney School District.
  - 3. Caesar Rodney School District will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- E. Maintain an on-site log listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced.

- F. Provide a separate maintenance contract for specified maintenance service.
- G. Provide service and maintenance of transfer switches for one year from Date of Substantial Completion.

# END OF SECTION

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# SECTION 26 43 00 SURGE PROTECTIVE DEVICES

### PART 1 GENERAL

# 1.01 SECTION INCLUDES

- A. Surge protective devices for service entrance locations.
- B. Surge protective devices for distribution locations.

### 1.02 RELATED REQUIREMENTS

- A. Section 26 05 26 Grounding and Bonding.
- B. Section Wiring Devices: Receptacles with integral surge protection.
- C. Section 26 24 13 Switchboards.
- D. Section 26 24 16 Panelboards.
- E. Section 27 10 05 Structured Cabling for Voice and Data: Protectors for communications service entrance.

## 1.03 ABBREVIATIONS AND ACRONYMS

- A. EMI/RFI: Electromagnetic Interference/Radio Frequency Interference.
- B. SPD: Surge Protective Device.

### 1.04 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction.
- B. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. NETA ATS Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- D. NFPA 70 National Electrical Code.
- E. UL 1449 Standard for Surge Protective Devices.

#### 1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate size and location of overcurrent device compatible with the actual surge protective device and location to be installed. Notify StudioJAED of any conflicts or deviations from the contract documents to obtain direction prior to ordering equipment.

## 1.06 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Include detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), nominal discharge current (I-n), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.
  - 1. SPDs with EMI/RFI filter: Include noise attenuation performance.
- C. Shop Drawings: Include wiring diagrams showing all factory and field connections with wire and circuit breaker/fuse sizes.
- D. Certificates: Manufacturer's documentation of listing for compliance with the following standards:
  - 1. UL 1449.
  - 2. UL 1283 (for Type 2 SPDs).

- E. Manufacturer's Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- F. Operation and Maintenance Data: Include information on status indicators and recommended maintenance procedures and intervals.
- G. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Caesar Rodney School District's name and registered with manufacturer.
- H. Project Record Documents: Record actual connections and locations of surge protective devices.

### 1.07 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

# 1.08 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in accordance with manufacturer's written instructions.

### **1.09 FIELD CONDITIONS**

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

## 1.10 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Manufacturer's Warranty: Provide minimum five year warranty covering repair or replacement of surge protective devices showing evidence of failure due to defective materials or workmanship.

# PART 2 PRODUCTS

# 2.01 MANUFACTURERS

- A. Basis of Design: Schneider Electric; Square D Brand Surgelogic Products as indicated under product article(s) below; www.surgelogic.com.
- B. Surge Protective Devices (SPD) as manufactured by Siemens Industry, Inc. are a permitted substitution with the inclusion of a Surge Counter and an External Operable Disconnect.
- C. Surge Protective Devices (SPD) as manufactured by Advanced Protection Technologies, Inc. are a permitted substitution with inclusion of an externally operable switch / breaker.
- D. Factory-installed, Internally Mounted Surge Protective Devices:
  - 1. Same as manufacturer of equipment containing surge protective device, to provide a complete listed assembly including SPD.
- E. Source Limitations: Furnish surge protective devices produced by a single manufacturer and obtained from a single supplier.

# 2.02 ALL SURGE PROTECTIVE DEVICES

- A. Description: Factory-assembled surge protective devices (SPDs) for 60 Hz service, listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated; system voltage as indicated on the drawings.
- B. Protected Modes:
  - 1. Wye Systems: L-N, L-G, N-G, L-L.

- C. UL 1449 Voltage Protection Ratings (VPRs):
  - 1. Equivalent to basis of design.
  - 2. 480Y/277V System Voltage: Not more than 1,500 V for L-N, L-G, and N-G modes and 2,000 V for L-L mode.
- D. UL 1449 Maximum Continuous Operating Voltage (MCOV): Not less than 115% of nominal system voltage.
- E. Enclosure Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
  - 1. Indoor clean, dry locations: Type 1.
- F. Mounting for Field-installed, Externally Mounted SPDs: Unless otherwise indicated, as specified for the following locations:
- G. Equipment Containing Factory-installed, Internally Mounted SPDs: Listed and labeled as a complete assembly including SPD.
  - 1. Switchboards: See Section 26 24 13.

# 2.03 SURGE PROTECTIVE DEVICES FOR SERVICE ENTRANCE LOCATIONS

- A. Unless otherwise indicated, provide field-installed, externally mounted or factory-installed, internally mounted SPDs.
- B. List and label as complying with UL 1449, Type 1 when connected on line side of service disconnect overcurrent device and Type 1 or 2 when connected on load side of service disconnect overcurrent device.
- C. Provide SPDs utilizing field-replaceable modular or non-modular protection circuits.
- D. Surge Current Rating: Not less than 120 kA per mode/240 kA per phase.
- E. Repetitive Surge Current Capacity: Not less than 5,000 impulses.
- F. UL 1449 Nominal Discharge Current (I-n): 20 kA.
- G. UL 1449 Short Circuit Current Rating (SCCR): Not less than the available fault current at the installed location as indicated on the drawings.
- H. Diagnostics:
  - 1. Protection Status Monitoring: Provide indicator lights to report the protection for each phase.
  - 2. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.
- I. Basis of Design: Schneider Electric; Square D Brand Surgelogic Products; www.surgelogic.com.
  - 1. Field-installed, Externally Mounted Surge Protective Devices:
    - a. EMA Series: Replaceable modules; 200 kA SCCR; individually fused MOVs, thermal fusing; dry contacts; EMI/RFI filtering; surge counter; duty cycle tested for 20,000 impulses; 10 year warranty.
  - 2. Factory-installed, Internally Mounted Surge Protective Devices:
    - a. IMA Series: Replaceable modules; 200 kA SCCR; individually fused MOVs, thermal fusing; dry contacts; EMI/RFI filtering; surge counter; duty cycle tested for 20,000 impulses; 10 year warranty.

# 2.04 SURGE PROTECTIVE DEVICES FOR DISTRIBUTION LOCATIONS

- A. Unless otherwise indicated, provide field-installed, externally mounted or factory-installed, internally mounted SPDs.
- B. List and label as complying with UL 1449, Type 1 or Type 2.
- C. Provide SPDs utilizing field-replaceable modular or non-modular protection circuits.

- D. Surge Current Rating: Not less than 80 kA per mode/160 kA per phase.
- E. UL 1449 Nominal Discharge Current (I-n): 20 kA.
- F. UL 1449 Short Circuit Current Rating (SCCR): Not less than the available fault current at the installed location as indicated on the drawings.
- G. Diagnostics:
  - 1. Protection Status Monitoring: Provide indicator lights to report the protection status for each phase.
  - 2. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.
- H. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch or not direct bus connected.
- I. Basis of Design: Schneider Electric; Square D Brand Surgelogic Products; www.surgelogic.com.
  - 1. Field-installed, Externally Mounted Surge Protective Devices:
    - a. EMA Series: Replaceable modules; 200 kA SCCR; individually fused MOVs, thermal fusing; dry contacts; EMI/RFI filtering; surge counter; duty cycle tested for 20,000 impulses; 10 year warranty.
      - 1) Furnished with integral switch option where indicated.
  - 2. Factory-installed, Internally Mounted Surge Protective Devices:
    - a. IMA Series: Replaceable modules; 200 kA SCCR; individually fused MOVs, thermal fusing; dry contacts; EMI/RFI filtering; surge counter; duty cycle tested for 20,000 impulses; 10 year warranty.

# PART 3 EXECUTION

# 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that the service voltage and configuration marked on the SPD are consistent with the service voltage and configuration at the location to be installed.
- C. Verify that electrical equipment is ready to accept connection of the SPD and that installed overcurrent device is consistent with requirements of the drawings and manufacturer's instructions.
- D. Verify system grounding and bonding is in accordance with Section 26 05 26, including bonding of neutral and ground for service entrance and separately derived systems where applicable. Do not energize SPD until deficiencies have been corrected.
- E. Verify that conditions are satisfactory for installation prior to starting work.

# 3.02 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1.
- B. Install SPD in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide conductors with minimum ampacity as indicated on the drawings, as required by NFPA 70, and not less than manufacturer's recommended minimum conductor size.
- E. Install conductors between SPD and equipment terminations as short and straight as possible, not exceeding manufacturer's recommended maximum conductor length. Breaker locations may be reasonably be rearranged in order to provide leads as short and straight as possible. Twist conductors together to reduce inductance.

F. Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 26 05 26 where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.

## 3.03 FIELD QUALITY CONTROL

- A. Perform inspection, testing, and adjusting in accordance with Section 01 40 00.
- B. Inspect and test in accordance with NETA STD ATS, except Section 4.
- C. Perform inspections and tests listed in NETA STD ATS Section 7.19.1.
- D. Procure services of a qualified manufacturer's representative to observe installation and assist in inspection, testing, and adjusting. Include manufacturer's reports with field quality control submittals.

## 3.04 CLEANING

A. Repair scratched or marred exterior surfaces to match original factory finish.

# END OF SECTION

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# SECTION 26 51 00 INTERIOR LIGHTING

## PART 1 GENERAL

# 1.01 SECTION INCLUDES

- A. Interior luminaires.
- B. Emergency lighting units.
- C. Exit signs.
- D. Ballasts.
- E. Lamps.
- F. Luminaire accessories.

# 1.02 RELATED REQUIREMENTS

- A. Section 26 05 37 Boxes.
- B. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- C. Section 26 09 23 Lighting Control Devices: Automatic controls for lighting including occupancy sensors, outdoor motion sensors, time switches, outdoor photo controls, and daylighting controls.
- D. Section 26 27 26 Wiring Devices: Manual wall switches and wall dimmers.
- E. Section 26 56 00 Exterior Lighting.

# 1.03 REFERENCE STANDARDS

- A. ANSI C78.379 American National Standard for Electric Lamps -- Reflector Lamps -- Classification of Beam Patterns.
- B. ANSI C82.1 American National Standard for Lamp Ballast Line Frequency Fluorescent Lamp Ballast.
- C. ANSI C82.4 American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type).
- D. ANSI C82.11 American National Standard for Lamp Ballasts High Frequency Fluorescent Lamp Ballasts Supplements.
- E. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.
- F. IES LM-79 Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products; Illuminating Engineering Society.
- G. IES LM-80 Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules; Illuminating Engineering Society.
- H. NECA 1 Standard for Good Workmanship in Electrical Construction.
- I. NECA/IESNA 500 Standard for Installing Indoor Commercial Lighting Systems.
- J. NECA/IESNA 502 Standard for Installing Industrial Lighting Systems.
- K. NEMA WD 6 Wiring Devices Dimensional Requirements; National Electrical Manufacturers Association.
- L. NFPA 70 National Electrical Code.
- M. NFPA 101 Life Safety Code.
- N. UL 924 Emergency Lighting and Power Equipment.

- O. UL 935 Fluorescent-Lamp Ballasts.
- P. UL 1598 Luminaires.
- Q. UL 8750 Light Emitting Diode (LED) Equipment for Use in Lighting Products.

## 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
  - 2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
  - 3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
  - 4. Notify StudioJAED of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

#### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Shop Drawings:
  - 1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
  - 2. Provide photometric calculations where luminaires are proposed for substitution upon request.
- C. Shop Drawings: Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
- D. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.
  - 1. LED Luminaires:
    - a. Include estimated useful life, calculated based on IES LM-80 test data.
    - b. Include IES LM-79 test report upon request.
- E. Sustainable Design Documentation: Submit manufacturer's product data on lamp mercury content and rated lamp life, showing compliance with specified requirements.
- F. Field Quality Control Reports.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- I. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
  - 2. Extra Lenses and Louvers: Two percent of total quantity installed for each type, but not less than one of each type.

- 3. Extra Lamps: Ten percent of total quantity installed for each type, but not less than two of each type.
- 4. Extra Ballasts: Two percent of total quantity installed for each type, but not less than one of each type.
- J. Project Record Documents: Record actual connections and locations of luminaires and any associated remote components.

### 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Conform to requirements of NFPA 70 and NFPA 101.
- D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

# 1.07 DELIVERY, STORAGE, AND PROTECTION

- A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

### **1.08 FIELD CONDITIONS**

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

# 1.09 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide two year manufacturer warranty for all linear fluorescent ballasts.

#### 1.10 EXTRA MATERIALS

- A. See Section 01 6000 Product Requirements, for additional provisions.
- B. Furnish two of each plastic lens type.
- C. Furnish one replacement lamps for each lamp type.
- D. Furnish two of each ballast type.

# PART 2 PRODUCTS

# 2.01 MANUFACTURERS

- A. Acuity Brands, Inc; : www.acuitybrands.com.
- B. Hubbell Lighting, Inc; : www.hubbelllighting.com.
- C. Lightolier: www.lightolier.com.
- D. Lithonia Lighting: www.lithonia.com.
- E. Columbia Lighting.
- F. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 LUMINAIRES

- A. Manufacturers:
  - 1. Acuity Brands, Inc; : www.acuitybrands.com.
  - 2. Cooper Lighting, a division of Cooper Industries; : www.cooperindustries.com.
  - 3. Hubbell Lighting, Inc; : www.hubbelllighting.com.

- 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Provide products that comply with requirements of NFPA 70.
- C. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- D. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- E. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- F. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.
- G. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- H. LED Luminaires:
  - 1. Components: UL 8750 recognized or listed as applicable.
  - 2. Tested in accordance with IES LM-79 and IES LM-80.
  - 3. LED Estimated Useful Life: Minimum of 200,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
- I. LED Luminaires: Listed and labeled as complying with UL 8750.
- J. Track Lighting Systems: Provide track compatible with specified track heads, with all connectors, power feed fittings, dead ends, hangers and canopies as necessary to complete installation.
- K. Luminaires Mounted in Continuous Rows: Provide quantity of units required for length indicated, with all accessories required for joining and aligning.

# 2.03 EMERGENCY LIGHTING UNITS

- A. Manufacturers:
  - 1. Acuity Brands, Inc; : www.acuitybrands.com.
  - 2. Cooper Lighting, a division of Cooper Industries; : www.cooperindustries.com.
  - 3. Hubbell Lighting, Inc; : www.hubbelllighting.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924. Emergency and Exit light combination unit with (2) unit mounted lamps and LED exit light with battery backup. Thois cmobination unit shall have spare capacity to power remote emergency lamp heads.
- C. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
- D. Battery:
  - 1. Sealed maintenance-free nickel cadmium unless otherwise indicated.
  - 2.
  - 3. Size battery to supply all connected lamps, including emergency remote heads where indicated.
- E. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
- F. Provide low-voltage disconnect to prevent battery damage from deep discharge.

- G. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.
- H. Accessories:
  - 1. Provide compatible accessory mounting brackets where indicated or required to complete installation.
  - 2. Provide compatible accessory high impact polycarbonate vandal shields where indicated.
  - 3. Provide compatible accessory wire guards where indicated.
  - 4. Where indicated, provide emergency remote heads that are compatible with the emergency lighting unit they are connected to and suitable for the installed location.

### 2.04 LUMINAIRES

- A. Furnish products as indicated in Schedule attached to this section.
- B. Substitutions: See Section 01 60 00 Product Requirements.
  - 1. Input Voltage: 120 or 277 volts.

# 2.05 EXIT SIGNS

- A. Manufacturers:
  - 1. Acuity Brands, Inc; : www.acuitybrands.com.
  - 2. Cooper Lighting, a division of Cooper Industries; : www.cooperindustries.com.
  - 3. Hubbell Lighting, Inc; : www.hubbelllighting.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Exit Signs: Internally illuminated with LEDs unless otherwise indicated; complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
  - 1. Number of Faces: Single or double as indicated or as required for the installed location.
  - 2. Directional Arrows: As indicated or as required for the installed location.
- C. Self-Powered Exit Signs:
  - 1. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
  - 2. Battery: Sealed maintenance-free nickel cadmium unless otherwise indicated.
  - 3. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
  - 4. Provide low-voltage disconnect to prevent battery damage from deep discharge.
  - 5. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.
- D. Accessories:
  - 1. Provide compatible accessory high impact polycarbonate vandal shields where indicated.
  - 2. Provide compatible accessory wire guards where indicated.
- E. Manufacturers: As indicated on lighting fixture schedule.
  - 1. Substitutions: See Section 01 60 00 Product Requirements.
- F. Exit Signs: Exit sign fixture .
  - 1. Housing: Plastic.
  - 2. Face: Translucent glass face with red letters on white background.
  - 3. Face: Aluminum stencil face with red letters.
  - 4. Directional Arrows: Universal type for field adjustment.
  - 5. Mounting: Universal, for field selection.
  - 6. Battery: 12 volt, nickel-cadmium type, with 1.5 hour capacity.

- 7. Battery Charger: Dual-rate type, with sufficient capacity to recharge discharged battery to full charge within twelve hours.
- 8. Lamps: Manufacturer's standard.
- 9. Input Voltage: 120/277 volts.

# 2.06 BALLASTS

- A. Manufacturers:
  - 1. General Electric Company/GE Lighting; : www.gelighting.com.
  - 2. Osram Sylvania; : www.sylvania.com.
  - 3. Philips Lighting Electronics/Advance; : www.advance.philips.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
  - 5. Manufacturer Limitations: Where possible, for each type of luminaire provide ballasts produced by a single manufacturer.
- B. All Ballasts:
  - 1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
  - 2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.
- C. Fluorescent Ballasts:
  - 1. All Fluorescent Ballasts: Unless otherwise indicated, provide high frequency electronic ballasts complying with ANSI C82.11 and listed and labeled as complying with UL 935.
    - a. Input Voltage: Suitable for operation at voltage of connected source, with variation tolerance of plus or minus 10 percent.
    - b. Total Harmonic Distortion: Not greater than 10 percent.
    - c. Power Factor: Not less than 0.95.
    - d. Thermal Protection: Listed and labeled as UL Class P, with automatic reset for integral thermal protectors.
    - e. Sound Rating: Class A, suitable for average ambient noise level of 20 to 24 decibels.
    - f. Lamp Compatibility: Specifically designed for use with the specified lamp, with no visible flicker.
    - g. Lamp Operating Frequency: Greater than 20 kHz, except as specified below.
      - 1) Do not operate lamp(s) within the frequencies from 30 kHz through 40 kHz in order to avoid interference with infrared devices.
    - h. Lamp Current Crest Factor: Not greater than 1.7.
    - i. Provide automatic restart capability to restart replaced lamp(s) without requiring resetting of power.
    - j. Provide end of lamp life automatic shut down circuitry for T5 and smaller diameter lamp ballasts.
    - k. Surge Tolerance: Capable of withstanding characteristic surges according to IEEE C62.41.2, location category A.
    - I. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 18, for Class A, non-consumer application.
    - m. Provide high efficiency T8 lamp ballasts certified as NEMA premium where indicated.
    - n. Ballast Marking: Include wiring diagrams with lamp connections.
  - 2. Non-Dimming Fluorescent Ballasts:
    - a. Lamp Starting Method:
      - 1) T8 Lamp Ballasts: Programmed start unless otherwise indicated.
      - 2) T5 Lamp Ballasts: Programmed start unless otherwise indicated.
      - 3) Compact Fluorescent Lamp Ballasts: Programmed start unless otherwise indicated.
Lamp Starting Temperature: Capable of starting standard lamp(s) at a minimum of 0 degrees F, and energy saving lamp(s) at a minimum of 60 degrees F unless otherwise indicated.

## 2.07 LAMPS

- A. Manufacturers:
  - 1. General Electric Company/GE Lighting; : www.gelighting.com.
  - 2. Osram Sylvania; : www.sylvania.com.
  - 3. Philips Lighting Company; : www.lighting.philips.com.
  - 4. Philips Lighting Co of NA: www.lighting.philips.com.
  - 5. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Lamps:
  - 1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
  - 2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.
  - 3. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
  - 4. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the StudioJAED to be inconsistent in perceived color temperature.
- C. Compact Fluorescent Lamps: Wattage and bulb type as indicated, with base type as required for luminaire.
  - 1. Low Mercury Content: Provide lamps that pass the EPA Toxicity Characteristic Leaching Procedure (TCLP) test for characteristic hazardous waste.
  - 2. Correlated Color Temperature (CCT): 3,500 K unless otherwise indicated.
  - 3. Color Rendering Index (CRI): Not less than 80.
  - 4. Average Rated Life: Not less than 10,000 hours for an operating cycle of three hours per start.
- D. Linear Fluorescent Lamps: Wattage and bulb type as indicated, with base type as required for luminaire.
  - 1. Low Mercury Content: Provide lamps that pass the EPA Toxicity Characteristic Leaching Procedure (TCLP) test for characteristic hazardous waste.
  - 2. T8 Linear Fluorescent Lamps:
    - a. Correlated Color Temperature (CCT): 3,500 K unless otherwise indicated.
    - b. Color Rendering Index (CRI): Not less than 80.
    - c. Average Rated Life: Not less than 20,000 hours for an operating cycle of three hours per start.
  - 3. T5 Linear Fluorescent Lamps:
    - a. Correlated Color Temperature (CCT): 3,500 K unless otherwise indicated.
    - b. Color Rendering Index (CRI): Not less than 80.
    - c. Average Rated Life: Not less than 20,000 hours for an operating cycle of three hours per start.
- E. Lamp Types: As specified for each luminaire.
- F. Fluorescent Lamps:
  - 1. Product: Phillips Lighting Type T5 or T8.
  - 2. Substitutions: See Section 01 60 00 Product Requirements.
- G. High Intensity Discharge (HID) Lamps:
  - 1. Product: Match Lighting Fixture Type
  - 2. Substitutions: See Section 01 60 00 Product Requirements.

## 2.08 ACCESSORIES

- A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.
- B. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4" size, field-painted as directed.
- C. Provide accessory plaster frames for luminaires recessed in plaster ceilings.
- D. Tube Guards for Linear Fluorescent Lamps: Provide clear virgin polycarbonate sleeves with endcaps where indicated.
- E. Product: As indicated in lighting fixture schedule.
  - 1. Substitutions: See Section 01 60 00 Product Requirements.

# PART 3 EXECUTION

## 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

## 3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

#### 3.03 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 26 05 37 as required for installation of luminaires provided under this section.
- B. Install products according to manufacturer's instructions.
- C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 1 (general workmanship), NECA 500 (commercial lighting), and NECA 502 (industrial lighting).
- D. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- E. Suspended Ceiling Mounted Luminaires:
  - 1. Do not use ceiling tiles to bear weight of luminaires.
  - 2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
  - 3. Secure pendant-mounted luminaires to building structure.
  - 4. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
  - In addition to ceiling support wires, provide two galvanized steel safety wire(s), minimum 12 gage, connected from opposing corners of each recessed luminaire to building structure.
  - 6. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.
- F. Recessed Luminaires:
  - 1. Install trims tight to mounting surface with no visible light leakage.
  - 2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.

- 3. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.
- G. Suspended Luminaires:
  - 1. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
  - 2. Install canopies tight to mounting surface.
- H. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- I. Install fixtures securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting).
- J. Install suspended luminaires and exit signs using pendants supported from swivel hangers. Provide pendant length required to suspend luminaire at indicated height.
- K. Support luminaires independent of ceiling framing.
- L. Locate recessed ceiling luminaires as indicated on reflected ceiling plan.
- M. Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prevent movement.
- N. Exposed Grid Ceilings: Support surface mounted luminaires in grid ceiling directly from building structure.
- O. Exposed Grid Ceilings: Provide auxiliary members spanning ceiling grid members to support surface mounted luminaires.
- P. Exposed Grid Ceilings: Fasten surface mounted luminaires to ceiling grid members using bolts, screws, rivets, or suitable clips.
- Q. Install recessed luminaires to permit removal from below.
- R. Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.
- S. Install clips to secure recessed grid-supported luminaires in place.
- T. Install wall mounted luminaires, emergency lighting units, and exit signs at height as scheduled.
- U. Install accessories furnished with each luminaire.
- V. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.
- W. Bond products and metal accessories to branch circuit equipment grounding conductor.
- X. Install specified lamps in each emergency lighting unit, exit sign, and luminaire.
- Y. Air Handling Luminaires: Interface with air handling accessories furnished and installed under Section 23 36 00.
- Z. Emergency Lighting Units:
  - Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- AA. Exit Signs:
  - 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- AB. Install lamps in each luminaire.

AC. Lamp Burn-In: Operate lamps at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

## 3.04 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Perform field inspection, testing, and adjusting in accordance with Section 01 4000.
- D. Operate each luminaire after installation and connection to verify proper operation.
- E. Test self-powered exit signs, emergency lighting units, and fluorescent emergency power supply units to verify proper operation upon loss of normal power supply.
- F. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by StudioJAED.

# 3.05 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by StudioJAED. Secure locking fittings in place.
- B. Aim and position adjustable emergency lighting unit lamps to achieve optimum illumination of egress path as required or as directed by StudioJAED or authority having jurisdiction.
- C. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by StudioJAED or authority having jurisdiction.
- D. Aim and adjust luminaires as indicated.
- E. Position exit sign directional arrows as indicated.

#### 3.06 CLEANING

- A. Clean surfaces according to NECA 500 (commercial lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.
- B. Clean electrical parts to remove conductive and deleterious materials.
- C. Remove dirt and debris from enclosures.
- D. Clean photometric control surfaces as recommended by manufacturer.
- E. Clean finishes and touch up damage.

# 3.07 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 Closeout Submittals, for closeout submittals.
- B. Just prior to Substantial Completion, replace all lamps that have failed.

# 3.08 PROTECTION

A. Protect installed luminaires from subsequent construction operations.

# 3.09 PROTECTION

A. Relamp luminaires that have failed lamps at Substantial Completion.

# 3.10 SCHEDULE - ATTACHED

# END OF SECTION

# SECTION 26 56 00 EXTERIOR LIGHTING

# PART 1 GENERAL

# 1.01 SECTION INCLUDES

- A. Exterior luminaires.
- B. Ballasts.
- C. Lamps.
- D. Poles and accessories.
- E. Luminaire accessories.

## 1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 Cast-in-Place Concrete: Materials and installation requirements for concrete bases for poles.
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- C. Section 26 05 37 Boxes.
- D. Section 26 27 26 Wiring Devices: Receptacles for installation in poles.
- E. Section 26 28 13 Fuses.
- F. Section 26 51 00 Interior Lighting.

## 1.03 REFERENCE STANDARDS

- A. AASHTO LTS Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals; American Association of State Highway and Transportation Officials.
- B. ANSI O5.1 American National Standard for Wood Poles -- Specifications and Dimensions.
- C. IESNA LM-63 ANSI Approved Standard File Format for Electronic Transfer of Photometric Data and Related Information.
- D. IES LM-80 Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules; Illuminating Engineering Society.
- E. IESNA LM-64 Photometric Measurements of Parking Areas.
- F. NECA 1 Standard for Good Workmanship in Electrical Construction.
- G. NECA/IESNA 501 Standard for Installing Exterior Lighting Systems.
- H. NFPA 70 National Electrical Code.
- I. UL 1598 Luminaires.
- J. UL 8750 Light Emitting Diode (LED) Equipment for Use in Lighting Products.

# 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc. installed under other sections or by others. Coordinate elevation to obtain specified foundation height.
  - 2. Notify StudioJAED of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

#### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Shop Drawings:

- 1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
- 2. Provide photometric calculations where luminaires are proposed for substitution .
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, weight, effective projected area (EPA), and installed accessories; include model number nomenclature clearly marked with all proposed features.
  - 1. LED Luminaires:
    - a. Include estimated useful life, calculated based on IES LM-80 test data.
  - 2. Provide electronic files of photometric data certified by a National Voluntary Laboratory Accreditation Program (NVLAP) lab or independent testing agency in IESNA LM-63 standard format upon request.
  - 3. Lamps: Include rated life and initial and mean lumen output.
  - 4. Poles: Include information on maximum supported effective projected area (EPA) and weight for the design wind speed.
- D. Sustainable Design Documentation: Submit manufacturer's product data on lamp mercury content and rated lamp life, showing compliance with specified requirements.
- E. Certificates for Poles and Accessories: Manufacturer's documentation that products are suitable for the luminaires to be installed and comply with designated structural design criteria.
- F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- G. Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- H. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.
- I. Project Record Documents: Record actual connections and locations of pole foundations, luminaires, and any pull or junction boxes.

### **1.06 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

# 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.
- C. Receive, handle, and store wood poles in accordance with ANSI O5.1.

# 1.08 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

# PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Acuity Brands, Inc; : www.acuitybrands.com.
- B. Hubbell Lighting, Inc; : www.hubbelllighting.com.
- C. Substitutions: See Section 01 60 00 Product Requirements.

#### 2.02 LUMINAIRE TYPES

- A. Furnish products as indicated in luminaire schedule included on the Drawings.
- B. Substitutions: See Section 01 60 00 Product Requirements.

## 2.03 LUMINAIRES

- A. Manufacturers:
  - 1. Acuity Brands, Inc; : www.acuitybrands.com.
  - 2. Hubbell Lighting, Inc; : www.hubbelllighting.com.
  - 3. Substitutions: See Section 01 60 00 Product Requirements.
- B. Provide products that comply with requirements of NFPA 70.
- C. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- D. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- E. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- F. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, poles, foundations, supports, trims, accessories, etc. as necessary for a complete operating system.
- G. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- H. Provide luminaires listed and labeled as suitable for wet locations unless otherwise indicated.
- I. LED Luminaires: Listed and labeled as complying with UL 8750.
- J. Exposed Hardware: Stainless steel.

#### 2.04 BALLASTS

- A. Manufacturers:
  - 1. General Electric Company/GE Lighting; : www.gelighting.com.
  - 2. Osram Sylvania; : www.sylvania.com.
  - 3. Philips Lighting Electronics/Advance; : www.advance.philips.com.
  - 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Ballasts:
  - 1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
  - 2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.

## 2.05 LAMPS

- A. Manufacturers:
  - 1. General Electric Company/GE Lighting; : www.gelighting.com.

- 2. Osram Sylvania; : www.sylvania.com.
- 3. Philips Lighting Company; : www.lighting.philips.com.
- 4. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Lamps:
  - 1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
  - 2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.
  - 3. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
  - 4. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the StudioJAED to be inconsistent in perceived color temperature.

## 2.06 POLES

- A. Manufacturers:
  - 1. Acuity Brands, Inc; : www.acuitybrands.com.
  - 2. Hubbell Lighting, Inc; : www.hubbelllighting.com.
  - 3. Substitutions: See Section 01 60 00 Product Requirements.
- B. All Poles:
  - 1. Provide poles and associated support components suitable for the luminaire(s) and associated supports and accessories to be installed.
  - 2. Structural Design Criteria:
    - a. Comply with AASHTO LTS.
    - b. Wind Load: Include effective projected area (EPA) of luminaire(s) and associated supports and accessories to be installed.
      - 1) Design Wind Speed: 100 miles per hour, with gust factor of 1.3.
    - c. Dead Load: Include weight of proposed luminaire(s) and associated supports and accessories.
  - 3. Material: Steel, unless otherwise indicated.
  - 4. Shape: Square straight, unless otherwise indicated.
  - 5. Finish: Match luminaire finish, unless otherwise indicated.
  - 6. Mounting: Install on concrete foundation, height as indicated on the drawings, unless otherwise indicated.
  - 7. Unless otherwise indicated, provide with the following features/accessories:
    - a. Top cap and metallic base cover.
    - b. Handhole.
    - c. Anchor bolts with leveling nuts or leveling shims.
    - d. Anchor base cover.
    - e. Pole-top tenon, size as required for installed luminaire or bracket.
- C. Metal Poles: Provide ground lug, accessible from handhole or transformer base.

# 2.07 ACCESSORIES

- A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.
- B. Provide accessory plaster frames for luminaires recessed in plaster ceilings.

# PART 3 EXECUTION

#### 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.

- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

## 3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

## 3.03 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 26 05 37 as required for installation of luminaires provided under this section.
- B. Install products according to manufacturer's instructions.
- C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 1 (general workmanship) and NECA/IESNA 501 (exterior lighting).
- D. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- E. Recessed Luminaires:
  - 1. Install trims tight to mounting surface with no visible light leakage.
  - 2. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.
- F. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- G. Install accessories furnished with each luminaire.
- H. Bond products and metal accessories to branch circuit equipment grounding conductor.
- I. Install lamps in each luminaire.

# 3.04 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Operate each luminaire after installation and connection to verify proper operation.
- D. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by StudioJAED.

# 3.05 ADJUSTING

A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by StudioJAED. Secure locking fittings in place.

## 3.06 CLEANING

A. Clean surfaces according to NECA/IESNA 501 and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

# 3.07 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of luminaires to StudioJAED, and correct deficiencies or make adjustments as directed.
- D. Just prior to Substantial Completion, replace all lamps that have failed.

# 3.08 PROTECTION

A. Protect installed luminaires from subsequent construction operations.

END OF SECTION

## SECTION 27 10 05

#### STRUCTURED CABLING FOR VOICE AND DATA - INSIDE-PLANT

# PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Communications system design requirements.
- B. Communications pathways.
- C. Fiber optic cable and interconnecting devices.
- D. Communications equipment room fittings.
- E. Communications outlets.
- F. Communications grounding and bonding.
- G. Communications identification.

## 1.02 RELATED REQUIREMENTS

- A. Section 07 84 00 Firestopping.
- B. Section 26 05 37 Boxes.

## 1.03 REFERENCE STANDARDS

- A. ICEA S-83-596 Indoor Optical Fiber Cables; Insulated Cable Engineers Association.
- B. NFPA 70 National Electrical Code.
- C. TIA-455-21 FOTP-21 Mating Durability of Fiber Optic Interconnecting Devices.
- D. TIA-492AAAD Detail Specification for 850-nm Laser-Optimized, 50-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers; Telecommunications Industry Association.
- E. TIA-526-14 Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant.
- F. TIA-568-C.3 Optical Fiber Cabling Components Standard.
- G. TIA-598-C Optical Fiber Cable Color Coding.
- H. TIA-606 Administration Standard for Telecommunications Infrastructure.
- I. TIA-607-B Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
- J. UL 444 Communications Cables.
- K. UL 514C Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
- L. UL 1651 Fiber Optic Cable.

# 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for communications equipment.
  - 2. Coordinate arrangement of communications equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Notify StudioJAED/Engineer of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
  - 4. Coordinate requirements of this section with Owner.

## 1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.
- C. Shop Drawings: Show compliance with requirements on isometric schematic diagram of network layout, showing cable routings, telecommunication closets, rack and enclosure layouts and locations, service entrance, and grounding, prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
- D. Evidence of qualifications for installer.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- F. Field Test Reports.
- G. Project Record Documents: Prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
  - 1. Record actual locations of outlet boxes and distribution frames.
  - 2. Show as-installed color coding, pair assignment, polarization, and cross-connect layout.
  - 3. Identify distribution frames and equipment rooms by room number on contract drawings.

# 1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: At least 3 years experience manufacturing products of the type specified.
- B. Installer Qualifications: A company having at least 3 years experience in the installation and testing of the type of system specified, and:
  - 1. Supervisors and installers factory certified by manufacturers of products to be installed.
- C. Products: Listed, classified, and labeled as suitable for the purpose intended.

# 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Keep stored products clean and dry.

# 1.08 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a 2 year period after Date of Substantial Completion.
- C. Provide warranty as called out in applicable referenced State of Delaware standards/specifications

# PART 2 PRODUCTS

#### 2.01 SYSTEM DESIGN

- A. Provide a complete permanent system of cabling and pathways for voice and data communications, including cables, conduits and wireways, pull wires, support structures, enclosures and cabinets, and outlets.
- B. IMPORTANT!! PLEASE NOTE THAT this specification references the Delaware State-Wide Information And Architecture Standards, Standard ID: NE=Cabling-002, Title: Structured Cabling System Standards and Specifications for State-Managed Facilities, Domain: Network and Storage, Discipline: Cabling, Revision Date: 1/8/2016, Revision no.: 6, Original date: 7/21/2008. As such this document shall be considered as part of this specification. Unless otherwise shown and or specified, all work, materials, etc. called for in the above mentioned document shall be provided as shown and specified the above mentioned document and on the drawings.

## 2.02 PATHWAYS

A. Refer to above mentioned Delaware State-Wide Information And Architecture Standards as well as other project specifications and drawings.

# 2.03 FIBER OPTIC CABLE AND INTERCONNECTING DEVICES

- A. Fiber Optic Backbone Cable:
  - 1. Description: Tight buffered, non-conductive fiber optic cable complying with TIA-568-C.3, TIA-598-C, ICEA S-83-596 and listed as complying with UL 444 and UL 1651.
  - 2. Cable Type: Multimode, laser-optimized 50/125 um (OM4) complying with TIA-492AAAD.
  - 3. Cable Capacity: 12-fiber.
  - 4. Cable Applications:
    - a. Plenum Applications: Use listed NFPA 70 Type OFNP plenum cable.
  - 5. Cable Jacket Color:
    - a. Laser-Optimized Multimode Fiber (OM3/OM4): Color to be selected by Owner.
  - 6. Product(s):
    - a. Hubbell M/N HFCD15012P4 or approved equal.
- B. Fiber Optic Interconnecting Devices:
  - 1. Connector Type: Type SC.
  - 2. Connector Performance: 500 mating cycles, when tested in accordance with TIA-455-21.
  - 3. Maximum Attenuation/Insertion Loss: 0.3 dB.
  - 4. Product(s):
    - a. Hubbell M/N FSPSCDM6AQ or approved equal. Provide 1 of these per 2U fiber patch panel box.
    - b. Provide 5 blanks per 2U fiber patch panel box. Hubbell M/N FSPB or approved equal

#### 2.04 COMMUNICATIONS EQUIPMENT ROOM FITTINGS

A. Refer to above mentioned Delaware State-Wide Information And Architecture Standards as well as other project specifications and drawings.

## 2.05 COMMUNICATIONS OUTLETS

- A. Refer to above mentioned Delaware State-Wide Information And Architecture Standards as well as other project specifications and drawings.
- B. Outlet Boxes: Comply with Section 26 05 37.
  - 1. Provide depth as required to accommodate cable manufacturer's recommended minimum conductor bend radius.
- C. Wall Plates:
  - 1. Comply with system design standards and UL 514C.
  - 2. Accepts modular jacks/inserts.
  - 3. Capacity:

## 2.06 GROUNDING AND BONDING COMPONENTS

- A. Refer to above mentioned Delaware State-Wide Information And Architecture Standards as well as other project specifications and drawings.
- B. Comply with TIA-607-B.

#### 2.07 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606.
- B. Identification shall be as specified and directed by Owner at no additional cost to the Owner

# PART 3 EXECUTION

## 3.01 INSTALLATION - GENERAL

- A. Comply with Communication Service Provider requirements.
- B. Grounding and Bonding: Perform in accordance with TIA-607-B and NFPA 70.
- C. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- D. Refer to above mentioned Delaware State-Wide Information And Architecture Standards as well as other project specifications and drawings.

## 3.02 INSTALLATION OF EQUIPMENT AND CABLING

- A. Cabling:
  - 1. Do not bend cable at radius less than manufacturer's recommended bend radius; for unshielded twisted pair use bend radius of not less than 4 times cable diameter.
  - 2. Do not over-cinch or crush cables.
  - 3. Do not exceed manufacturer's recommended cable pull tension.
  - 4. When installing in conduit, use only lubricants approved by cable manufacturer and do not chafe or damage outer jacket.
- B. Identification:
  - 1. Use wire and cable markers to identify cables at each end.
  - 2. Use manufacturer-furnished label inserts, identification labels, or engraved wallplate to identify each jack at communications outlets with unique identifier.
  - 3. Use identification nameplate to identify cross-connection equipment, equipment racks, and cabinets.
  - 4. Identify components as directed by Owner at no additional cost to Owner.

# 3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Comply with inspection and testing requirements of specified installation standards.
- C. Visual Inspection:
  - 1. Inspect cable jackets for certification markings.
  - 2. Inspect cable terminations for color coded labels of proper type.
  - 3. Inspect outlet plates and patch panels for complete labels.
- D. Testing Copper Cabling and Associated Equipment:
  - 1. Test backbone cables after termination but before cross-connection.
  - 2. Test backbone cables for DC loop resistance, shorts, opens, intermittent faults, and polarity between connectors and between conductors and shield, if cable has overall shield.
  - 3. Test operation of shorting bars in connection blocks.
  - 4. Category 3 Backbone: Perform attenuation test.
  - 5. Category 3 Links: Test each pair for short circuit continuity, short to ground, crosses, reversed polarity, operational and ring-back, and dial tone.
  - 6. Category 5e and Above Backbone: Perform near end cross talk (NEXT) and attenuation tests.
  - 7. Category 5e and Above Links: Perform tests for wire map, length, attenuation, NEXT, and propagation delay.
  - 8. Refer to above mentioned Delaware State-Wide Information And Architecture Standards as well as other project specifications and drawings.
- E. Testing Fiber Optic Cabling:

- 1. Backbone: Perform optical fiber end-to-end attenuation test using an optical time domain reflectometer (OTDR) and manufacturer's recommended test procedures; perform verification acceptance tests and factory reel tests.
- 2. Multimode Backbone: Perform tests in accordance with TIA-526-14.
- 3. Links: Perform optical fiber end-to-end attenuation tests and field reel tests.
- 4. Refer to above mentioned Delaware State-Wide Information And Architecture Standards as well as other project specifications and drawings.

# END OF SECTION

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# SECTION 27 51 16 PUBLIC ADDRESS SYSTEMS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Amplifier and control equipment.
- B. Reproducer equipment.
- C. Sound system cable.

## 1.02 RELATED REQUIREMENTS

A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.

## 1.03 REFERENCE STANDARDS

A. NFPA 70 - National Electrical Code.

# **1.04 SYSTEM DESCRIPTION**

- A. Public address (PA) system for voice.
  - 1. Additional PA amplifiers, wiring, speakers, etc. shall be installed as an extension to the building's existing Bogen PA system as shown, specified, and required for a complete and operating PA system.
- B. Features:
  - 1. One-way paging by zone.

## 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements. Indicate layout of equipment mounted in racks and cabinets, component interconnecting wiring, and wiring diagrams of field wiring to speakers and remote input devices.
- C. Product Data: Provide data showing electrical characteristics and connection requirements for each component.
- D. Test Reports: Indicate satisfactory completion of each test recommended by the manufacturer.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- F. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- G. Project Record Documents: Record actual locations of speakers, control equipment, and outlets for input/output connectors.
- H. Operation Data: Include instructions for adjusting, operating, and extending the system.
- I. Maintenance Data: Include repair procedures and spare parts documentation.

#### 1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70 and Federal Communications Commission.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience with service facilities within 100 miles of Project.
- C. Supplier Qualifications: Authorized distributor of specified manufacturer with minimum three years documented experience.
- D. Installer Qualifications: Authorized installer of specified manufacturer with service facilities within 100 miles of Project.

E. Products: Listed, classified, and labeled as suitable for the purpose intended.

# PART 2 PRODUCTS

# 2.01 MANUFACTURERS

- A. Bogen Communications, Inc: www.bogen.com.
- B. Substitutions: See Section 01 60 00 Product Requirements.

# 2.02 AMPLIFICATION AND CONTROL EQUIPMENT

- A. Bogen Gold Seal Series Amplifier as called for on drawings
- B. System Cabinet: Rack mounted.

# 2.03 COMPONENTS

- A. Drop-In Ceiling Speakers: 8 inch coaxial speaker with integral crossover circuit.
  - 1. Power Rating: 4-0.5 watts.
  - 2. Frequency Range: 95 Hz to 20 kHz minimum
  - 3. Sound Pressure Level: 94 dB at 3 feet with 1 watt input.
  - 4. Magnet: 10 ounces
  - 5. Unit shall have a 70V/25V trandorrmer with power taps of 4, 2, 1, 0.5, and 0.25 watts selectable by rotary switch
  - 6. Unit shall have four seismic attachment points.
  - 7. UL listed 1480 for U.S. use
  - 8. Product: Bogen CSD2X2VRU or approved equal.
  - 9. Substitutions: See Section 01 60 00 Product Requirements.
  - 10. Fully enclosed and constructed of industrial grade steel
  - 11. Speaker shall have easily accessible front-mounted volume control.
- B. Wall Mounted Speakers: 8 inch cone speaker
  - 1. Magnet: 6 ounces
  - 2. Power Rating (max): 4 Watts
  - 3. Transformer Power Taps: 4, 2, 1, 1/2, 1/4, and 1/8 Watts
  - 4. Voltage: selectable 70V or 25V
  - 5. Frequency Repsonse: 110 Hz-15 kHz
  - 6. Sensitivity: 96 dBspl 91W @ 1m on axis
  - 7. Disperson: 100 deg
  - 8. Product: Bogen MB8TSLVR or approved equal
  - 9. Volume Control: recessed volume control centerin in the front speaker grille.
  - 10. Enclosure: Full steel construction to allow for surface mounting painted off-white with knockouts for wiremold
  - 11. Substitutions: See Section 01 60 00 Product Requirements.
- C. Horns: Wide dispersion indoor/outdoor horn with driver.
  - 1. See drawings

# 2.04 WIRE AND CABLE

A. Plenum Cable for Speaker Circuits: 22 AWG copper conductor, 300 volt insulation, rated 200 degrees C, paired conductors twisted together shielded and covered with a nonmetallic jacket; suitable for use for Class 2 circuits in air handling ducts, hollow spaces used as ducts, and plenums.

# PART 3 EXECUTION

# 3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

- B. Mounting Heights: Coordinate locations of outlet boxes specified in Section 26 05 37 to obtain mounting heights indicated on drawings.
- C. Splice cable only in accessible junction boxes or at terminal block units.
- D. Make cable shields continuous at splices and connect speaker circuit shield to equipment ground only at amplifier.
- E. Install input circuits in separate cables and raceways from output circuits.
- F. Leave 18 inches excess cable at each termination at microphone, volume pad, speaker, and other system outlet.
- G. Leave 6 feet excess cable at each termination at system cabinet
- H. Provide protection for exposed cables where subject to damage.
- I. Use armored cable for outside speaker circuits.
- J. Support cables above accessible ceilings to keep them from resting on ceiling tiles. Use spring metal clips or plastic cable ties to support cables from structure for ceiling suspension system. Include bridle rings or drive rings.
- K. Use suitable cable fittings and connectors.
- L. Connect reproducers to amplifier with matching transformers.
- M. Install equipment racks in location shown; arrange to provide adequate ventilation and access. Mount at rack position as dictated by Owner at no additional cost to the Owner.
- N. Ground and bond equipment and circuits in accordance with Section 26 05 26.

# 3.02 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Provide the services of manufacturer's technical representative to prepare and start system.
  - 1. Include making of final wiring connections, inspection and adjusting of completed installation, and systems demonstration.
  - 2. Certify that installation is complete and performs according to specified requirements.
- C. Measure and record sound power levels at designated locations.

# 3.03 ADJUSTING

- A. Volume Adjustements: Adjust transformer taps for appropriate sound level. Adjust to sound levels as directed by Owner. Contractor shall make initial adjustments to all speakers installed. Once adjusted and approved by Owner, Contractor shall provide at least two more visits to the site to further adjust up to 75% of all the speakers to new volume levels as directed and approved by Owner at no additional cost to the Owner.
- B. Adjust devices and wall plates to be flush and level.

#### 3.04 CLOSEOUT ACTIVITIES

- A. See Section 01 79 00 Demonstration and Training, for additional requirements.
- B. Demonstration: Demonstrate operation of system to Caesar Rodney School District's personnel.
  - 1. Use operation and maintenance data as reference during demonstration.
  - 2. Briefly describe function, operation, and maintenance of each component.
- C. Training: Train Caesar Rodney School District's personnel on operation and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.

3. Location: At project site.

# 3.05 MAINTENANCE

A. Provide service and maintenance of public address system for one year from Date of Substantial Completion.

# **END OF SECTION**

# SECTION 27 53 13 CLOCK SYSTEMS

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Clock system requirements.
- B. Wireless clock systems and associated components:
  - 1. Master clock unit.
  - 2. Wireless secondary indicating clocks.
- C. Accessories.

## 1.02 REFERENCE STANDARDS

- A. 47 CFR 15 Radio Frequency Devices.
- B. NECA 1 Standard for Good Workmanship in Electrical Construction.
- C. NFPA 70 National Electrical Code.

# 1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the placement of clocks with potential conflicts and/or view obstructions installed under other sections or by others.
  - 2. Coordinate the work with other installers to provide power for clocks and equipment at required locations.
  - 3. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install clocks until final surface finishes and painting are complete.

#### 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- C. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include elevations and details of proposed equipment arrangements. Include system interconnection schematic diagrams. Include requirements for interface with other systems.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- E. Manufacturer's detailed field testing procedures.
- F. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- G. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Caesar Rodney School District's name and registered with manufacturer.
- H. Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.

## 1.05 QUALITY ASSURANCE

- A. Comply with the following:
  - 1. NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Installer Qualifications: Company with minimum three years documented experience with similar clock systems and providing contract maintenance service as a regular part of their business; manufacturer's authorized installer.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.

## 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

#### **1.07 FIELD CONDITIONS**

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

### 1.08 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship. Warranty shall begin at date of project substantial completion and shall include parts and labor.

## PART 2 PRODUCTS

1.

#### 2.01 CLOCK SYSTEM REQUIREMENTS

- A. Interface with Existing Clock System:
  - Existing Master Clock Unit:
  - a. Manufacturer/Model: Primex XR System.
- B. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B, consumer application.

#### 2.02 WIRELESS CLOCK SYSTEMS

- A. Manufacturers:
  - 1. Wireless Clock System Basis of Design: Primex M/N 14155 for standard 12.5 inch clocks, and M/N 14163 for 16 inch clocks..
- B. Master Clock Unit:
  - 1. Basis of Design: Primex M/N XR01M.
  - 2. Description: Microprocessor-based controller and associated accessories for maintaining time reference and correcting connected wireless secondary indicating clocks.
  - 3. Acceptable Time Reference Source(s): Based on Network Time Protocol (NTP) server time data obtained via local area network (LAN) or Global Positioning System (GPS) satellite antenna/receiver.
  - 4. Wireless Time Correction Signal Transmitter/Antenna: Compatible with wireless secondary clocks, including any existing clocks.
- C. Analog Wireless Secondary Indicating Clocks 12.5 inch:
  - 1. Basis of Design: Primex M/N 14155.
  - 2. Power Source: Battery. Provide new batteries with each clock to ensure all new clocks are powered. Batteries shall be Duracell Copper Top size D batteries or approved equal.

- 3. Time Reference Source: Synchronized with master clock unit wireless time correction signal.
- 4. Clock Face:
  - a. Shape: Round.
  - b. Size: 12.5 inch, nominal.
  - c. Color: White face with black numerals and markings, unless otherwise indicated or approved by StudioJAED.
  - d. Hands: For indicating hour, minute, and second.
- 5. Clock Crystal/Lens: Shatter-resistant plastic.
- 6. Case Material/Color/Finish: Plastic/Black.
- 7. Mounting:
  - a. Single-Face Clocks: Surface.
- D. Analog Wireless Secondary Indicating Clocks 16 inch:
  - 1. Basis of Design: Primex M/N 14163.
  - 2. Power Source: Battery. Provide new batteries with each clock to ensure all new clocks are powered. Batteries shall be Duracell Copper Top size D batteries or approved equal.
  - 3. Time Reference Source: Synchronized with master clock unit wireless time correction signal.
  - 4. Clock Face:
    - a. Shape: Round.
    - b. Size: 16 inch, nominal.
    - c. Color: White face with black numerals and markings, unless otherwise indicated or approved by StudioJAED.
    - d. Hands: For indicating hour, minute, and second.
  - 5. Clock Crystal/Lens: Shatter-resistant plastic.
  - 6. Case Material/Color/Finish: Plastic/Black.
  - 7. Mounting:
    - a. Single-Face Clocks: Surface.
- E. Provide components as indicated or as required for extension of wireless time correction signal between master clock unit and wireless secondary indicating clocks.

#### 2.03 ACCESSORIES

- A. Provide components and wiring as indicated or as required for connection to auxiliary devices and other systems indicated.
- B. Protective Covers/Guards for Clocks: Where indicated.

# PART 3 EXECUTION

# 3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that characteristics of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that conditions are satisfactory for installation prior to starting work.

# 3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Provide grounding and bonding in accordance with Section 26 05 26.
- D. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.

E. Identify system wiring and components in accordance with Section 26 05 53.

# 3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Prepare and start system in accordance with manufacturer's instructions.
- C. Program system parameters according to requirements of Caesar Rodney School District.
- D. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.
- E. Submit detailed reports indicating inspection and testing results and corrective actions taken.

# 3.04 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

# 3.05 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of system to Caesar Rodney School District, and correct deficiencies or make adjustments as directed.
- D. Training: Train Caesar Rodney School District's personnel on operation, adjustment, and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Instructor: Manufacturer's authorized representative.
  - 4. Location: At project site.

# 3.06 PROTECTION

A. Protect installed system components from subsequent construction operations.

# 3.07 MAINTENANCE

- A. See Section 01 70 00 Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Conduct site visit upon Caesar Rodney School District's request within one year from Date of Substantial Completion to make additional adjustments to system programming.
- C. Provide trouble call-back service upon notification by Caesar Rodney School District:
  - 1. Include allowance for call-back service during normal working hours at no extra cost to Caesar Rodney School District.
  - 2. Caesar Rodney School District will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.

# END OF SECTION

# SECTION 28 13 00 ACCESS CONTROL

## PART 1 GENERAL

# 1.01 SECTION INCLUDES

- A. Access control system requirements.
- B. Access control units and software.
- C. Access control point peripherals, including readers.
- D. Accessories.

## 1.02 RELATED REQUIREMENTS

- A. Section 07 84 00 Firestopping.
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems.
- C. Section 26 05 34 Conduit.
- D. Section 26 05 53 Identification for Electrical Systems: Identification products and requirements.
- E. Section 28 16 00 Intrusion Detection: For interface with access control system.
- F. Section 28 23 00 Video Surveillance: For interface with access control system.
- G. Section 28 31 00 Fire Detection and Alarm: For interface with access control system.

## 1.03 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction.
- B. NFPA 70 National Electrical Code.
- C. NFPA 101 Life Safety Code.
- D. UL 294 Access Control System Units.

# 1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the work with other installers to provide suitable door hardware as required for both access control functionality and code compliance.
  - 2. Coordinate the placement of readers with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 3. Coordinate the work with other installers to provide power for equipment at required locations.
  - 4. Notify StudioJAED of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

#### 1.05 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include elevations and details of proposed equipment arrangements. Include system interconnection schematic diagrams. Include requirements for interface with other systems.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- D. Design Data: Standby battery/UPS calculations.
- E. Certify that proposed system design and components meet or exceed specified requirements.

- F. Evidence of qualifications for installer.
- G. Evidence of qualifications for maintenance contractor (if different entity from installer).
- H. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- I. Manufacturer's detailed field testing procedures.
- J. Field quality control test reports.
- K. Maintenance contracts.
- L. Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.
- M. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- N. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Caesar Rodney School District's name and registered with manufacturer.
- O. Software: One copy of software not resident in read-only memory.
- P. Maintenance Materials: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. See Section 01 60 00 Product Requirements, for additional provisions.

## 1.06 QUALITY ASSURANCE

- A. Comply with the following:
  - 1. NFPA 70
  - 2. NFPA 101 (Life Safety Code).
  - 3. The requirements of the local authorities having jurisdiction.
  - 4. Applicable TIA/EIA standards.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Installer Qualifications: Company specializing in performing the work of this section with minimum ten years documented experience with access control systems of similar size, type, and complexity and providing contract maintenance service as a regular part of their business; authorized manufacturer's representative. Installer shall be platinum certified by manufacturer.
   Contract maintenance office located within 30 miles of project site.
- E. Maintenance Contractor Qualifications: Same entity as installer.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

#### 1.08 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

### 1.09 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

### PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Access Control System
  - 1. All the components of the electronic access control system are to seamlessly integrate with the following existing EAC system:
    - a. Honeywell Prowatch. The system shall be an expansion of the existing system in the school.
- B. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.
- C. Source Limitations: Where possible, furnish system components and accessories produced by a single manufacturer and obtained from a single supplier.

## 2.02 ACCESS CONTROL SYSTEM REQUIREMENTS

- A. Provide new access control system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. System Battery Backup: Provide batteries/uninterruptible power supplies (UPS) as required.
- C. Access Control Points:
  - 1. See drawings.
- D. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
  - 1. Access Control Units and Readers: Listed and labeled as complying with UL 294.

# 2.03 ACCESS CONTROL UNITS AND SOFTWARE

- A. Provide access control units and associated software compatible with readers to be connected.
- B. Computers:
  - 1. Workstation Computers: Unless otherwise indicated, workstation computer hardware and associated peripherals not furnished by access control system manufacturer to be provided by Contractor as part of work of this section, meeting access control system equipment manufacturer's recommended requirements.
  - 2. Servers: Unless otherwise indicated, server hardware and associated peripherals not furnished by access control system manufacturer to be provided by Contractor as part of work of this section, meeting access control system equipment manufacturer's recommended requirements.
  - 3. Badging Peripherals: Unless otherwise indicated, badging peripherals not furnished by access control system manufacturer to be provided by Contractor as part of work of this section.
- C. Software:
  - 1. Unless otherwise indicated, provide all software and licenses required for fully operational system.

# 2.04 ACCESS CONTROL POINT PERIPHERALS

A. Provide devices compatible with control units.

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- B. Provide devices suitable for operation under the service conditions at the installed location.
- C. Provide readers compatible with credentials to be used.
- D. Reader Color: To be selected by Architect from manufacturer's available standard colors.
- E. Contactless Smart Card Readers:
  - 1. Shall be dual technology
    - 2. iclass Utilizing 13.56 Mhz RF and 125 kHz prox cards communication with compatible credentials.
    - 3. Utilizes 64 bit authentication keys.
    - 4. Supports ISO compliant credentials.
    - 5. Supports data encryption.

# 2.05 ACCESSORIES

- A. Provide components as indicated or as required for connection of access control system to devices and other systems indicated.
- B. Unless otherwise indicated, credentials to be provided by Contractor.
- 1. Provide credentials compatible with readers and control units/software to be used.
- C. Provide cables as indicated or as required for connections between system components.
- D. Provide accessory racks/cabinets as indicated or as required for equipment mounting.

# PART 3 EXECUTION

# 3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that ratings and configurations of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to system.
- E. Verify that conditions are satisfactory for installation prior to starting work.

# 3.02 INSTALLATION

- A. Install access control system in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Wiring Method: Unless otherwise indicated, use wiring in conduit.
  - 1. Use suitable listed cables in wet locations, including underground raceways.
  - 2. Use suitable listed cables for vertical riser applications.
  - 3. Conduit: Comply with Section 26 05 34.
  - 4. Use power transfer hinges complying with Section 08 71 00 for concealed connections to door hardware.
  - 5. Do not exceed manufacturer's recommended maximum cable length between components.
- D. Provide grounding and bonding in accordance with Section 26 05 26.
- E. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- F. Identify system wiring and components in accordance with Section 26 05 53.

# 3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

- B. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- C. Prepare and start system in accordance with manufacturer's instructions.
- D. Program system parameters according to requirements of Caesar Rodney School District.
- E. Test for proper interface with other systems.
- F. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.
- G. Submit detailed reports indicating inspection and testing results and corrective actions taken.

## 3.04 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

# 3.05 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of system to Caesar Rodney School District, and correct deficiencies or make adjustments as directed.
- D. Training: Train Caesar Rodney School District's personnel on operation, adjustment, and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of four hours of training.
  - 3. Instructor: Manufacturer's authorized representative.
  - 4. Location: At project site.

### 3.06 PROTECTION

A. Protect installed system components from subsequent construction operations.

# 3.07 MAINTENANCE

- A. See Section 01 70 00 Execution Requirements, for additional requirements relating to maintenance service.
- B. Provide to Caesar Rodney School District, a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of access control system for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.

#### END OF SECTION

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# SECTION 28 23 19 NETWORK VIDEO RECORDING SYSTEM

#### PART 1 GENERAL

## 1.01 SECTION INCLUDES

A. Provide a complete IP video recording system, including engineering, components, installation and commissioning.

# 1.02 RELATED SECTIONS

A. Not used

# 1.03 REFERENCES

- A. Reference Standards: Provide systems which meet or exceed the requirements of the following publications and organizations as applicable to the Work of this Section:
  - 1. Canadian ICES-003
  - 2. Consultative Committee for International Radio (CCIR)
  - 3. Conformity for Europe (CE)
  - 4. Electronic Industry Association (EIA)
  - 5. Federal Communications Commission (FCC)
  - 6. Joint Photographic Experts Group (JPEG)
  - 7. Moving Pictures Experts Group (MPEG)
  - 8. Motion Joint Photographic Experts Group (MJPEG)
  - 9. National Television Systems Committee (NTSC)
  - 10. Phase Alternating by Line (PAL)
  - 11. Underwriters Laboratories Inc. (UL)
  - 12. Institute for Electrical and Electronics Engineers (IEEE)
  - 13. ITU-T Video Coding Experts Group (VCEG)
  - 14. Physical Security Interoperability Alliance (PSIA)
  - 15. Open Network Video Interface Forum (ONVIF)
  - 16. Real Time Streaming Protocol (RTSP)

#### 1.04 DEFINITIONS

- A. HD (High-definition) refers to video having resolution substantially higher than traditional television systems. HD has one or two million pixels per frame.
- B. CIF (Common Intermediate Format) refers to a standard video format, which is categorized based on the resolution.

#### 1.05 SYSTEM DESCRIPTION

- A. The Network Video Recorder (NVR) supports simultaneous recording, remote viewing and search, and system management for up to 64 IP cameras including high definition formats. Multiple NVRs may be deployed for system expansion using a distributed architecture and integrated with the multi-site software or enterprise video management system.
- B. Basis-of-design is the Honeywell MAXPRO NVR PE.

#### 1.06 SUBMITTALS

- A. Manufacturer's Product Data: Submit manufacturer's data sheets indicating systems and components proposed for use, including instruction manuals.
- B. Shop Drawings: Submit complete shop drawings including connection diagrams for interfacing equipment, list of connected equipment, and locations for major equipment components.
- C. Record Drawings: During construction maintain record drawings indicating location of equipment and wiring. Submit an electronic version of record drawings not later than Substantial Completion of the project.

- D. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, customized to the system installed. Include system and operator manuals.
- E. Field Tests: Submit results of field testing of every device including date, testing personnel, retesting date if applicable, and confirmation that every device passed field testing.
- F. Maintenance Service Agreement: Submit a sample copy of the manufacturer's maintenance service agreement, including cost and services for a one year period for Owner's review. Maintenance shall include, but not be limited to; labor and materials to repair the system, provide test and adjustments, and regular inspections.

## 1.07 QUALITY ASSURANCE

- A. Manufacturer: Minimum ten years experience in manufacturing and maintaining IP video recording systems. Manufacturer shall provide toll-free technical assistance and support available 24/7.
- B. Manufacturing Location: Provide equipment assembled in the United States.
- C. Installer: Minimum ten years experience installing similar systems, and acceptable to the manufacturer of the IP video recording system and must be located within 30 miles of the project location. Integrator must employee a minimum of 5 manufacturer trained technicians on the specified product.
- D. Environmental Conditions: The NVR shall be designed to function in the following environmental conditions:
  - 1. Operating Temperature: 32°F to 95°F (0°C to 35°C).
  - 2. Emissions: FCC part 15B Class A; EN 55022 Class A
  - 3. Immunity: EN 50130-4
  - 4. Safety: ANSI / UL 60950-1; CAN / CSA C22.2 No. 60950-1; IEC 60950-1.
  - 5. RoHS: EN 50581
- E. Power Requirements: NVR shall have the following electrical specifications:
  - 1. Input Voltage: 110/220 VAC 50/60 Hz
  - 2. Operating Voltage: 110V/220V Auto Sensing
  - 3. Power Dissipation:
    - a. Average BTU rating = 880 BTU/HR
    - b. Peak BTU rating = 2800 BTU/HR

#### 1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's labeled packages. Store and handle in accordance with manufacturer's requirements, in a facility with environmental conditions within recommended limits.

#### 1.09 WARRANTY

A. Manufacturer's Warranty: The warranty period shall be thirty six (36) months from the date of project substantial completion.

# PART 2 PRODUCTS

# 2.01 MANUFACTURER

- A. Network Video Recording System (NVR) Manufacturer: Honeywell MAXPRO NVR PE Network Video Recording System, <u>www.honeywell.com/security</u>.
- B. Accepted Alternates: Refer to substitution procedures in section 01 60 00. Substitution requests will only be accepted for review prior to bid. After bids are submitted, substitutions will not be permitted.

## 2.02 SYSTEM COMPONENTS

- A. NVR Server: The NVR Server shall contain the recording engine, database of all network-connected cameras and encoders, integrated components and their configurations. Server shall be provided as a combined hardware and software device.
- B. Workstation Software (NVR Client): The NVR Client software shall render video and act as a main human/machine interface.

#### 2.03 OPERATIONAL REQUIREMENTS

- A. NVR shall provide a user-friendly graphical user interface (GUI) to configure the cameras, create schedules for recording, perform video surveillance and recording operations, and view various reports.
- B. NVR shall be configured to store and to view images captured by 64 cameras.
- C. NVR shall have following major capabilities:
  - Record and monitor up to 64 IP channels at 1920 fps @ 4CIF/VGA or 1920 fps @ 720p HD or 1920 fps @ 1080p (4 Mbps bitrate) HD per MAXPRO NVR PE. Network bandwidth/throughput supported per NVR with Incoming: 256 Mbps, Outgoing: 425 Mbps providing a Total: 681 Mbps. Archival support of 25 channels @ 4 Mbps bitrate each (100 Mbps total archival throughput capacity per MAXPRO NVR PE), with outgoing archival storage throughput of 275 Mbps. Multi-stream support with maximum 128 streams per MAXPRO NVR PE. Support for configuring one (1) preferred stream for continuous recording and one (1) preferred stream for live video/motion based recording per camera. Support for One-Way Audio (for specific IP cameras) with live, playback and clip export on NVR desktop client for up to 64 IP channels.
  - 2. Live viewing of up to 64 IP cameras on a single remote workstation with up to two (2) monitors set up at CIF resolution. For 4CIF and HD resolution, the number of live streams needs to be benchmarked based on client hardware configuration deployed. Cost-effective enhanced HD video rendering on remote desktop clients with support for monitoring of up to 23 1080p HD cameras in real time (30 fps)/690 fps 1080p HD with no-time lapse using the GPU capabilities of in-built processor graphics with 6th generation Intel® Core™ Processors for client systems. Up to 4 1080p HD @ 30 fps/120 fps on local client.
  - 3. Powerful investigation and video archive search tools from remote client.
  - Native device integrations supporting equIP® Series cameras' new features: 4K resolution, H.265 video compression codec, 3D PTZ control, 360° camera support, and intelligence events.
  - 5. Capable of managing motion detection-based recording with pre-event and post-event recording based on camera based motion detection or Server based motion detection events (SMART VMD) and "advanced" search on recordings from remote client.
  - Preview and Calendar Search permitting search for videos and events based on user-selected date and time from remote client. SMART motion search - fast and efficient forensic search and investigation for objects/motion on recorded video using Honeywell SMART motion detection Analytics algorithms on the client PC without impacting the NVR Server load.
  - 7. Simultaneous use of multiple video compressions including MJPEG, MPEG-4, H.265 and H.264.
  - 8. Internationalization supports the following languages: French, German, Russian, Italian, Spanish, Dutch, Arabic and English.
  - 9. Email on alarm.
  - 10. Instant clip creation from snapshot.
  - 11. Dynamic IP Camera Discovery Automatically discover all compatible cameras connected to NVR.
  - 12. Multi-level user access rights for viewing and manages access to the recorder functions.

- 13. Capable of managing continuous, scheduled, manual, event-based, and alarm-based recording features.
- 14. Advanced security features with encryption support for communication between desktop client to NVR and secure https login for Web Client and mobile apps.
- 15. Support for web client and mobile apps.
- D. Mode for User Login: NVR shall have the option of two modes of user logins:
  - 1. Windows Authentication: Uses Windows logged-in user name.
  - 2. User DB Authentication: Uses preconfigured user name and password.
- E. Workstation (NVR Client) shall provide the following operator options:
  - 1. Configuration: The operator (with Administrator privileges) shall have the option to configure the NVR. Live update of all configurations is supported. The following configurations shall be possible:
    - a. System Configuration: Provide options to configure the system level settings.
    - b. Camera Configuration: Provide options to add/edit/delete IP cameras and encoders.
    - c. Schedules: Provide options to configure schedule based recording for cameras connected to the NVR.
    - d. Input and Output: Provide options to configure camera input and output.
    - e. Sequences: Provide options to group a fixed number of cameras to view video.
    - f. User Management (Users and Roles): Provide option to add/edit/delete users.
    - g. Clip Deletion Settings: Provide the ability to automatically utilize more storage on event-initiated recording.
    - h. Independent deletion setting for continuous recording.
    - i. Independent deletion setting for event recording.
    - j. Surrounding Cameras: Provide option to grant a user the ability to view a single camera surrounded by the cameras programmed as the "Surrounding Cameras".
    - k. 3D Positioning: The user shall be able to view a specific object in the live video in a 3-dimensional view. This feature is available in the Context menu options and is only supported with New equIP PTZs HDZ302DE, HDZ302D, and HDZ302DIN. 3D positioning options include: Click-based camera positioning, Rectangle selection 3D positioning, and Restore to last PTZ position.
    - I. Profile Cameras: Multi-zoom views on HD video and support to create virtual cameras by digitally zooming into the field of view. For example: zooming in on a cash register in one view of the HD camera while at the same time monitoring the cashier in the zoomed out view of that HD camera.
- F. Configurations for cameras connected to NVR:
  - 1. Camera Configuration: The user shall be able to configure the following parameters for each camera connected to the NVR.
    - a. Camera Name
    - b. IP Address
    - c. Camera Type
    - d. Fixed/PTZ
    - e. Continuous Recording: All cameras added shall be defaulted to "24/7" recording with the option to select other recording modes.
    - f. Event Based Recording: Shall be "None" by default, with the option to select motion-based recording.
    - g. User name: Shall display and enable setting the user name for a camera.
    - h. Password: Shall enable setting the password for a camera.
    - Camera Advanced Settings: Shall enable configuration of Video Format, Compression Format, Resolution, Compression, Video Frame Rate, GOP, Record Quality Settings, Clip Deletion Settings, Launching Web View of camera for Advanced Setup, Motion detection zones configuration for Server based motion detection, Video

Archival Settings, Multi-Stream Settings and Video Preview. Shall enable configuration of RTSP URL for cameras or encoders added with camera type - Generic RTSP.

- 2. The following video recording options shall be supported:
  - a. Scheduled based recording: The system shall support the ability to schedule recordings for each individual camera for times in the future. By default, the NVR shall be pre-loaded with the following four schedules: 24x7, Weekday, Daytime, and Nighttime, which cannot be edited. A maximum of 50 schedules can be created in the NVR.
  - b. User based recording: The user shall be able to configure user activated settings for recording moments of interest while viewing live video from a camera. After configuring the user activated settings, the operator can start recording of video when needed. The video is recorded for the time period specified in the System settings for user activated recording. The User based Recording Time Duration shall be selectable from a list of values ranging between 30 seconds and 5 minutes.
  - c. Event based recording: Event based recording shall be possible on SMART Video Motion Detection and alarm triggers. The NVR must be capable of managing motion detection-based recording with pre-event and post event recording based on camera and Server-based motion detection events. The server-based SMART VMD analytics must be object-based and not traditional pixel-based, reducing false alarms due to changing light conditions, video noise, rain or other false alarm triggers that occur using pixel-based (traditional) VMD.
- G. Viewer: The NVR Viewer shall have the following minimum capabilities:
  - 1. Main video viewing screen capable of showing 1, 4, 9, 16, and other customized split salvos of live or recorded video. Standard presets shall be customizable to the user preferences.
  - 2. Capable of saving current salvo as a View and allowing the user to drag this view at any later point in time.
  - 3. Capable of configuring and running scan sequences.
  - 4. Capable of adjusting the contrast, brightness, and saturation settings for each camera independently.
  - 5. Capable of exporting user selected image or video clips in simple .wmv, .asf, .mpvc and .bmp formats. Capable of attaching a digital signature for authentication of exported clips in .wmv format.
  - 6. Capability to play back the video clips exported. Each video channel that is being recorded by the recording system shall be overlaid with text and a time stamp that is customizable by the user.
  - 7. MAXPRO Video Container (.mpvc) format support only playable in MAXPRO desktop clients and standalone Clip Player. Features quicker exports of raw video and support for estimating clip size and split to multiple clips to ensure clip storage media matches. Include the clip player with exported clip for easier review of video evidence and efficient investigation. Clip Player Portable standard secure player for archived and exported clips (\*.mpvc), 360 camera de-warping and 2x2 Salvo support. Smooth playback support with up to 256x review speed. No software needed to run on a Windows PC, with the option to include the clip player with the exported clip.
  - 8. Allow the user to initiate recording through the GUI or a controller.
  - 9. Capability of complete alarm management for the alarms coming from the NVR.
  - 10. Facility of surrounding camera view.
  - 11. Option to perform various operations through context menu on a particular video (live/recorded/sequence). These operations include: Full screen, point and drag, maintain aspect ratio, toggle text, digital PTZ, add bookmark, start recording, stop recording, mark in, mark out, save image, save image as, show surrounding cameras.

- 12. Ability to manage timeline control of the recording device, which provides camera recording statistics. Timeline control shall have the following features: Mark input (with looping facility), bookmark, snapshot, time slider, time jump, play controls.
- 13. Preference configuration including: frame rate of unselected panels, rendered type, preview pane, text display format.
- H. Search: The Search facility shall include search for recorded video and events based on date and time.
- I. Reports: The Report facility shall include event history report and audit log report.

# 2.04 NVR INTEGRATIONS

- A. NVR shall be compatible with the following interoperability standards:
  - 1. Physical Security Interoperability Alliance (PSIA)
  - 2. Open Network Video Interface Forum Profile S (ONVIF Profile S)
  - 3. Real Time Streaming Protocol (RTSP)
- B. NVR shall be compatible with the following Fixed and PTZ IP cameras
  - 1. Honeywell Performance Series, equIP® Series and New equIP® Series IP cameras
  - 2. Supports IP cameras from the following manufacturers. Please contact Honeywell for the complete list of manufacturers and models.
    - a. AXIS® Communications
    - b. Sony
    - c. Panasonic
    - d. Bosch
    - e. Samsung
    - f. Vivotek
    - g. Pelco
- C. NVR shall be compatible with the following encoders:
  - 1. Honeywell HVE Series Encoders
  - 2. Supports Encoders from the following manufacturers. Please contact Honeywell for the complete list of manufacturers and models.
    - a. AXIS® Communications
    - b. Sony
    - c. Panasonic
    - d. Bosch
    - e. Samsung
    - f. Vivotek
- D. NVR shall be compatible with the following 360° Camera solutions. Please contact Honeywell for the complete list of models.
  - 1. Honeywell equIP® Series Fisheye IP Cameras: HFD6GR1
  - 2. Oncam Grandeye
  - 3. Immervision Enables® Panomorph Lenses
  - 4. AXIS® 360°/180°
  - 5. Arecont 360°/180°
- E. NVR shall be compatible with the following Video Management Systems:
  1. Honeywell MAXPRO® VMS
- F. NVR shall be compatible with the following Access Control Security System:
  - 1. Honeywell Pro-Watch® Access Control System through MAXPRO® VMS and MAXPRO® Viewer
- G. Video Analytics supported through MAXPRO® VMS:
  - 1. Honeywell Active Alert
## 2.05 SYSTEM HARDWARE

- A. MAXPRO NVR PE Server: NVR Server shall operate with no performance degradation using the following minimum hardware and operating system configuration:
  - 1. 2U 8 bay storage unit with SAS hard drives
  - 2. Processor: Intel® Core™ i7-4790, 3.6 GHz, Intel® HD Graphics 4600
  - 3. Memory: 8 GB
  - 4. Power supply: Dual redundant 820 W
  - 5. OS Drives: 2 x 2.5" 128 GB SATA solid state drives, RAID 1 support
  - 6. Operating system: Windows Embedded Standard 7, 64-bit SP1
  - 7. Database: Microsoft SQL Server Express 2008 R2
  - 8. Storage capacities: 4 TB to 48 TB raw storage, Video storage redundancy with RAID 5/6 support
  - 9. Video Storage Hard Disk Options: 8 field-upgradable 1 TB, 2 TB, 3 TB, 4 TB or 6 TB SAS Hard Disk Drive options
  - 10. Optical drive: DVD-RW
  - 11. Network interface: Dual 1 Gigabit Ethernet
  - 12. RAID card: 6 GB SAS/SATA RAID card, PCI Express x8, supports RAID levels up to 6+0
  - 13. Human Interface: 102-key keyboard and a mouse pointing device
  - 14. Monitor Output: HDMI with DVI-D to HDMI adapter or VGA or DVI-D or Display Port (1 monitor support)
  - 15. Rack kit: Rack kit for use with 2U chassis
- B. NVR Workstation: NVR Workstation shall operate with no performance degradation using the following recommended hardware and operating system configuration for rendering up to twenty-three (23) 1080p HD cameras in real time (30 fps)/690 fps @ 1080p HD with no time-lapse. Workstation configuration assumes two-monitor setup. Workstation is required for remote clients only; a local client is available on the NVR PE unit for configuration and monitoring. The performance specifications below are recommended for systems with fixed or PTZ cameras only. Oncam Grandeye 360 cameras and H.265 cameras are not supported with GPU rendering and use CPU rendering by default. On Windows 7 workstations, GPU rendering is only supported through the motherboard monitor outputs and any additional graphics cards should be disabled in BIOS. On Windows 8.1 and Windows 10 workstations with Intel GPU and any additional graphics cards, at least one monitor should be connected to the motherboard monitor output.
  - 1. Processor: Intel® Core<sup>™</sup> i7-6700, 3.4 GHz or equivalent 6th generation Intel® Core<sup>™</sup> Processors for client systems.
  - 2. Graphics Adapter: In-built Processor Graphics (GPU): Intel® HD Graphics 530, 4600 or equivalent.
  - 3. System Memory (RAM): 8 GB
  - 4. Optical Drive: DVD-RW
  - 5. Hard Disk Drives: Single Disk or RAID 0 or 0+1 10K SATA 80GB or 10K to 15K
  - 6. SAS 73 GB.
  - 7. Network Interface Card (NIC): 1 Gbps
  - 8. Human Interface: 102-key keyboard and a mouse pointing device
  - 9. Operating System: Microsoft® Windows 7 Professional 64-bit SP1, Windows 8.1 Professional 64-bit, or Windows 10 Professional 64-bit.

#### 2.06 MANUFACTURER SUPPORT

A. Manufacturer shall provide customer service, pre-sales applications assistance, after-sales technical assistance, access to technical online support, and online training using Web conferencing.

B. Manufacturer shall provide 24/7 technical assistance and support via a toll-free telephone number at no extra charge.

# PART 3 EXECUTION

## 3.01 EXAMINATION

A. Examine site conditions prior to installation. Notify Architect and Owner in writing if unsuitable conditions are encountered. Do not start installation until site conditions are acceptable.

## 3.02 INSTALLATION

- A. Test all components before shipping to the project location.
- B. NVR system shall be installed, programmed, and tested in accordance with manufacturer's installation instructions.
  - 1. Coordinate interfaces with Owner's representative where appropriate.
  - 2. Provide backboxes, racks, connectors, supports, conduit, cable, and wire for a complete and reliable installation. Obtain Owner's approval for exact location of all boxes, conduit, and wiring runs prior to installation.
  - 3. Install conduit, cable, and wire parallel and square with building lines, including raised floors areas. Do not exceed forty percent fill in conduits. Gather wires and tie to create an orderly installation.
  - 4. Coordinate with other trades to provide proper sequencing of installation.

## 3.03 FIELD COMMISSIONING AND CERTIFICATION

- A. Field Commissioning: Testing the IP Video Recording system as recommended by manufacturer, including the following:
  - 1. Conduct complete inspection and testing of equipment, including verification of operation with connected equipment.
  - 2. Test devices and demonstrate operational features for Owner's representative and authorities having jurisdiction as applicable.
  - 3. Correct deficiencies until satisfactory results are obtained.
  - 4. Submit written copies of test results.

## 3.04 TRAINING

A. Conduct on-site system administrator and security/surveillance operator training, with the number of sessions and length of sessions as recommended by the NVR system manufacturer. Training shall include administration, provisioning, configuration, operation, and diagnostics.

# SECTION 28 31 00 FIRE DETECTION AND ALARM

## PART 1 GENERAL

## 1.01 SECTION INCLUDES

- A. Fire alarm system design and installation, including all components, wiring, and conduit.
- B. Transmitters for communication with supervising station.
- C. Circuits from protected premises to supervising station, including conduit.
- D. Replacement and removal of existing fire alarm system components, wiring, and conduit indicated.
- E. Maintenance of fire alarm system under contract for specified warranty period.

## 1.02 RELATED REQUIREMENTS

- Α.
- B. Section 08 71 00 Door Hardware: Electrically operated locks and door holder devices to be monitored and released by fire alarm system.
- C. Section 21 30 00 Fire Pumps: Supervisory devices.
- D. Section 21 13 00 Fire-Suppression Sprinkler Systems: Supervisory, alarm, and actuating devices installed in sprinkler system.
- E. Section 14 20 10 Passenger Elevators: Elevator systems monitored and controlled by fire alarm system.
- F. Section 23 33 00 Air Duct Accessories: Smoke dampers monitored and controlled by fire alarm system.

## 1.03 REFERENCE STANDARDS

- A. 36 CFR 1191 Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines.
- B. IEEE C62.41.2 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.
- C. NFPA 70 National Electrical Code.
- D. NFPA 72 National Fire Alarm and Signaling Code.

# 1.04 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Proposal Documents: Submit the following with cost/time proposal:
  - 1. NFPA 72 "Record of Completion", filled out to the extent known at the time.
  - 2. Manufacturer's detailed data sheet for each control unit, initiating device, and notification appliance.
  - 3. Certification by Contractor that the system design will comply with the contract documents.
  - 4. Proposed maintenance contract.
- C. Drawings must be prepared using AutoCAD Release 11\_.
  - 1. Caesar Rodney School District will provide floor plan drawings for Contractor's use; verify all dimensions on Caesar Rodney School District-provided drawings.
- D. Evidence of designer qualifications.
- E. Design Documents: Submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, riser diagrams, and description of operation:
  - 1. Copy (if any) of list of data required by authority having jurisdiction.

- 2. NFPA 72 "Record of Completion", filled out to the extent known at the time.
- 3. Clear and concise description of operation, with input/output matrix similar to that shown in NFPA 72 Appendix A-7-5-2.2(9), and complete listing of software required.
- 4. System zone boundaries and interfaces to fire safety systems.
- 5. Location of all components, circuits, and raceways; mark components with identifiers used in control unit programming.
- 6. Circuit layouts; number, size, and type of raceways and conductors; conduit fill calculations; spare capacity calculations; notification appliance circuit voltage drop calculations.
- 7. List of all devices on each signaling line circuit, with spare capacity indicated.
- 8. Manufacturer's detailed data sheet for each component, including wiring diagrams, installation instructions, and circuit length limitations.
- 9. Description of power supplies; if secondary power is by battery include calculations demonstrating adequate battery power.
- 10. Certification by either the manufacturer of the control unit or by the manufacturer of each other component that the components are compatible with the control unit.
- 11. Certification by the manufacturer of the control unit that the system design complies with the contract documents.
- 12. Certification by Contractor that the system design complies with the contract documents.
- 13. Do not show existing components to be removed.
- F. Evidence of installer qualifications.
- G. Evidence of instructor qualifications; training lesson plan outline.
- H. Evidence of maintenance contractor qualifications, if different from installer.
- I. Inspection and Test Reports:
  - 1. Submit inspection and test plan prior to closeout demonstration.
  - 2. Submit documentation of satisfactory inspections and tests.
  - 3. Submit NFPA 72 "Inspection and Test Form," filled out.
- J. Operating and Maintenance Data: See Section 01 78 00 for additional requirements; revise and resubmit until acceptable; have one set available during closeout demonstration:
  - 1. Complete set of specified design documents, as approved by authority having jurisdiction.
  - 2. Additional printed set of project record documents and closeout documents, bound or filed in same manuals.
  - 3. Contact information for firm that will be providing contract maintenance and trouble call-back service.
  - 4. List of recommended spare parts, tools, and instruments for testing.
  - 5. Replacement parts list with current prices, and source of supply.
  - 6. Detailed troubleshooting guide and large scale input/output matrix.
  - 7. Preventive maintenance, inspection, and testing schedule complying with NFPA 72; provide printed copy and computer format acceptable to Caesar Rodney School District.
  - 8. Detailed but easy to read explanation of procedures to be taken by non-technical administrative personnel in the event of system trouble, when routine testing is being conducted, for fire drills, and when entering into contracts for remodeling.
- K. Project Record Documents: See Section 01 78 00 for additional requirements; have one set available during closeout demonstration:
  - 1. Complete set of floor plans showing actual installed locations of components, conduit, and zones.
  - 2. "As installed" wiring and schematic diagrams, with final terminal identifications.
  - 3. "As programmed" operating sequences, including control events by device, updated input/output chart, and voice messages by event.
- L. Closeout Documents:

- 1. Certification by manufacturer that the system has been installed in compliance with his installation requirements, is complete, and is in satisfactory operating condition.
- 2. NFPA 72 "Record of Completion", filled out completely and signed by installer and authorized representative of authority having jurisdiction.
- 3. Certificate of Occupancy.
- 4. Maintenance contract.
- M. Maintenance Materials, Tools, and Software: Furnish the following for Caesar Rodney School District's use in maintenance of project.
  - 1. Furnish spare parts of same manufacturer and model as those installed; deliver in original packaging, labeled in same manner as in operating and maintenance data and place in spare parts cabinet.
  - 2. In addition to the items in quantities indicated in PART 2, furnish the following:
    - a. All tools, software, and documentation necessary to modify the fire alarm system using Caesar Rodney School District's personnel; minimum modification capability to include addition and deletion of devices, circuits, and zones, and changes to system description, operation, and evacuation and instructional messages.
    - b. One copy, on CD-ROM, of all software not resident in read-only-memory.

## 1.05 QUALITY ASSURANCE

- A. Copies of Design Criteria Documents: Maintain at the project site for the duration of the project, bound together, an original copy of NFPA 72, the relevant portions of applicable codes, and instructions and guidelines of authorities having jurisdiction; deliver to Caesar Rodney School District upon completion.
- B. Designer Qualifications: NICET Level III or IV (3 or 4) certified fire alarm technician or registered fire protection engineer, employed by fire alarm control panel manufacturer, Contractor, or installer, with experience designing fire alarm systems in the jurisdictional area of the authorities having jurisdiction.
- C. Installer Qualifications: Firm with minimum 3 years documented experience installing fire alarm systems of the specified type and providing contract maintenance service as a regular part of their business.
  - 1. Authorized representative of control unit manufacturer; submit manufacturer's certification that installer is authorized; include name and title of manufacturer's representative making certification.
  - 2. Installer Personnel: At least 2 years of experience installing fire alarm systems.
  - 3. Supervisor: NICET level III or IV (3 or 4) certified fire alarm technician; furnish name and address.
  - 4. Certified in Delaware as fire alarm installer.
- D. Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.
- E. Instructor Qualifications: Experienced in technical instruction, understanding fire alarm theory, and able to provide the required training; trained by fire alarm control unit manufacturer.

## 1.06 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide control panel manufacturer's warranty that system components other than wire and conduit are free from defects and will remain so for 1 year after date of Substantial Completion.
- C. Provide installer's warranty that the installation is free from defects and will remain so for 1 year after date of Substantial Completion.

## PART 2 PRODUCTS

## 2.01 MANUFACTURERS

- A. Fire Alarm Control Units Basis of Design: Notifier.
- B. Fire Alarm Control Units Other Acceptable Manufacturers: Provided their products meet or exceed the performance of the basis of design product, products of the following are acceptable:
  - 1. Honeywell Security & Fire Solutions/Notifier: www.notifier.com.
  - 2. Honeywell Security & Fire Solutions/Silent Knight: www.silentknight.com.
  - 3. Provide all control units made by the same manufacturer.
- C. Initiating Devices, and Notification Appliances:
  - 1. Honeywell Security & Fire Solutions/Notifier: www.notifier.com.
  - 2. Honeywell Security & Fire Solutions/Silent Knight: www.silentknight.com.
  - 3. Siemens Building Technologies, Inc: www.sbt.siemens.com.
  - 4. Same manufacturer as control units.
  - 5. Provide all initiating devices and notification appliances made by the same manufacturer.
- D. Substitutions: See Section 01 60 00 Product Requirements.
  - 1. For other acceptable manufacturers of control units specified, submit product data showing equivalent features and compliance with contract documents.
  - 2. For substitution of products by manufacturers not listed, submit product data showing features and certification by Contractor that the design will comply with contract documents.

# 2.02 FIRE ALARM SYSTEM

- A. Fire Alarm System: Provide a new, complete automatic fire detection and alarm system with control panel, annuciator, and all interconnecting wiring, power supplies, and appurtenances as necessary for a fully operating sytem:
  - 1. Provide all components necessary, regardless of whether shown in the contract documents or not.
  - 2. Protected Premises: Entire building shown on drawings.
  - 3. Comply with the following; where requirements conflict, order of precedence of requirements is as listed:
    - a. ADA Standards for Accessible Design.
    - b. The requirements of the State Fire Marshal.
    - c. The requirements of the local authority having jurisdiction, which is the State of Maryland.
    - d. Applicable local codes.
    - e. The contract documents (drawings and specifications).
    - f. NFPA 72; where the word "should" is used consider that provision mandatory; where conflicts between requirements require deviation from NFPA 72, identify deviations clearly on design documents.
  - 4. Evacuation Alarm: Multiple smoke zones; allow for evacuation notification of any individual zone or combination of zones, in addition to general evacuation of entire premises.
  - 5. Voice Notification: Provide emergency voice/alarm communications with multichannel capability; digital.
  - 6. General Evacuation Zones: Each smoke zone is considered a general evacuation zone unless otherwise indicated, with alarm notification in all zones on the same floor, on the floor above, and the floor below.
  - 7. Program notification zones and voice messages as directed by Caesar Rodney School District.

- 8. Hearing Impaired Occupants: Provide visible notification devices in all public areas and in dwelling units.
- 9. Fire Command Center: Location indicated on drawings.
- 10. Master Control Unit (Panel): New, located at fire command center.
- B. Supervising Stations and Fire Department Connections:
  - 1. Public Fire Department Notification: By on-premises supervising station.
  - 2. On-Premises Supervising Station: Existing proprietary station operated by Caesar Rodney School District, located at \_\_\_\_\_.
  - 3. Means of Transmission to On-Premises Supervising Station: Directly connected noncoded system.
  - 4. Means of Transmission to Remote Supervising Station: Provide United Security Products, Inc. AD-2001 Automatic Voice Dialer - No Substitutions.
- C. Circuits:
  - 1. Initiating Device Circuits (IDC): Class A, Style D.
  - 2. Signaling Line Circuits (SLC) Within Single Building: Class A, Style 7.
  - 3. Notification Appliance Circuits (NAC): Class A, Style Z.
- D. Spare Capacity:
  - 1. Initiating Device Circuits: Minimum 25 percent spare capacity.
  - 2. Notification Appliance Circuits: Minimum 25 percent spare capacity.
  - 3. Speaker Amplifiers: Minimum 25 percent spare capacity.
  - 4. Master Control Unit: Capable of handling all circuits utilized to capacity without requiring additional components other than plug-in control modules.
- E. Power Sources:
  - 1. Primary: Dedicated branch circuits of the facility power distribution system.
  - 2. Secondary: Storage batteries.
  - 3. Capacity: Sufficient to operate entire system for period specified by NFPA 72.
  - 4. Each Computer System: Provide uninterruptible power supply (UPS).

### 2.03 EXISTING COMPONENTS

- A. Existing Fire Alarm System: Remove existing system completely inlcuding, but not limited to, abandoned devices in concealed spaces.
- B. On-Premises Supervising Station: Include as part of this work all modifications necessary to existing supervising station to accommodate new fire alarm work.
- C. Clearly label components that are "Not In Service."
- D. Remove unused existing components and materials from site and dispose of properly.

## 2.04 FIRE SAFETY SYSTEMS INTERFACES

- A. Supervision: Provide supervisory signals in accordance with NFPA 72 for the following:
  - 1. Sprinkler water control valves.
  - 2. Dry-pipe sprinkler system pressure.
  - 3. Dry-pipe sprinkler valve room low temperature.
  - 4. Fire pump(s).
  - 5. Elevator shut-down control circuits.
  - 6. Dialer not to be activated in Supervisory condition.
- B. Alarm: Provide alarm initiation in accordance with NFPA 72 for the following:
  - 1. Sprinkler water flow.
  - 2. Kitchen hood suppression activation; also disconnect fuel source from cooking equipment.
  - 3. Elevator lobby, elevator hoistway, and elevator machine room smoke detectors.
  - 4. Duct smoke detectors.

- C. Elevators:
  - 1. Elevator lobby, hoistway, and machine room smoke detectors: Elevator recall for fire fighters' service.
  - 2. Elevator Machine Room Heat Detector: Shut down elevator power prior to hoistway sprinkler activation.
  - 3. Sprinkler pressure or waterflow: Shut down elevator power prior to hoistway sprinkler activation.
- D. HVAC:
  - 1. Duct Smoke Detectors: Close dampers indicated; shut down air handlers indicated.

## 2.05 COMPONENTS

- A. General:
  - 1. Provide flush mounted units where installed in finish areas; in unfinished areas, surface mounted unit are acceptable.
  - 2. Provide legible, permanent labels for each control device, using identification used in operation and maintenance data.
- B. Fire Alarm Control Units, Initiating Devices, and Notification Appliances: Analog, addressable type; listed by Underwriters Laboratories as suitable for the purpose intended.
- C. Master Control Unit: As specified for Basis of Design above, or equivalent.
- D. Remote Annunciators: \_\_\_\_\_.
- E. Initiating Devices:
  - 1. Manual Pull Stations: \_\_\_\_\_. a. Provide 1 extra.
  - 2. Key Operated Pull Stations: \_\_\_\_\_.
  - 3. Smoke Detectors: \_\_\_\_\_. a. Provide 1 extra.
  - Duct Smoke Detectors: \_\_\_\_\_.
    a. Provide 1 extra.
  - 5. Heat Detectors:
  - 6. Addressable Interface Devices: \_\_\_\_\_.
- F. Notification Appliances:
  - 1. Bells: .
  - 2. Speakers: \_\_\_\_\_.
  - 3. Strobes: \_\_\_\_\_
    - a. Provide 1 extra.
  - 4. Horn Strobes
    - a. Provide 1 extra.
- G. Circuit Conductors: Copper or optical fiber; provide 200 feet extra; color code and label.
- H. Surge Protection: In accordance with IEEE C62.41.2 category B combination waveform and NFPA 70; except for optical fiber conductors.
- I. Locks and Keys: Deliver keys to Caesar Rodney School District.
- J. Instruction Charts: Printed instruction chart for operators, showing steps to be taken when a signal is received (normal, alarm, supervisory, and trouble); easily readable from normal operator's station.
  - 1. Frame: Stainless steel or aluminum with polycarbonate or glass cover.
  - 2. Provide one for each control unit where operations are to be performed.
  - 3. Obtain approval of Caesar Rodney School District prior to mounting; mount in location acceptable to Caesar Rodney School District.

4. Provide extra copy with operation and maintenance data submittal.

## PART 3 EXECUTION

## 3.01 INSTALLATION

- A. Install in accordance with applicable codes, NFPA 72, NFPA 70, and the contract documents.
- B. Conceal all wiring, conduit, boxes, and supports where installed in finished areas.
- C. Obtain Caesar Rodney School District's approval of locations of devices, before installation.
- D. Install instruction cards and labels.

## 3.02 INSPECTION AND TESTING FOR COMPLETION

- A. Notify Caesar Rodney School District 7 days prior to beginning completion inspections and tests.
- B. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- C. Provide the services of the installer's supervisor or person with equivalent qualifications to supervise inspection and testing, correction, and adjustments.
- D. Prepare for testing by ensuring that all work is complete and correct; perform preliminary tests as required.
- E. Provide all tools, software, and supplies required to accomplish inspection and testing.
- F. Perform inspection and testing in accordance with NFPA 72 and requirements of local authorities; document each inspection and test.
- G. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.

## 3.03 CAESAR RODNEY SCHOOL DISTRICT PERSONNEL INSTRUCTION

- A. Provide the following instruction to designated Caesar Rodney School District personnel:
  - 1. Hands-On Instruction: On-site, using operational system.
  - 2. Classroom Instruction: Caesar Rodney School District furnished classroom, on-site or at other local facility.
- B. Administrative: One-hour session(s) covering issues necessary for non-technical administrative staff; classroom:
  - 1. Initial Training: 1 session pre-closeout.
- C. Basic Operation: One-hour sessions for attendant personnel, security officers, and engineering staff; combination of classroom and hands-on:
  - 1. Initial Training: 1 session pre-closeout.
- D. Furnish the services of instructors and teaching aids; have copies of operation and maintenance data available during instruction.

## 3.04 CLOSEOUT

- A. Closeout Demonstration: Demonstrate proper operation of all functions to Caesar Rodney School District.
  - 1. Be prepared to conduct any of the required tests.
  - 2. Have at least one copy of operation and maintenance data, preliminary copy of project record drawings, input/output matrix, and operator instruction chart(s) available during demonstration.
  - 3. Have authorized technical representative of control unit manufacturer present during demonstration.
  - 4. Demonstration may be combined with inspection and testing required by authority having jurisdiction; notify authority having jurisdiction in time to schedule demonstration.

- 5. Repeat demonstration until successful.
- B. Occupancy of the project will not occur prior to Substantial Completion.
- C. Substantial Completion of the project cannot be achieved until inspection and testing is successful and:
  - 1. Approved operating and maintenance data has been delivered.
  - 2. Spare parts, extra materials, and tools have been delivered.
  - 3. All aspects of operation have been demonstrated to Caesar Rodney School District.
  - 4. Final acceptance of the fire alarm system has been given by authorities having jurisdiction.
  - 5. Occupancy permit has been granted.
  - 6. Specified pre-closeout instruction is complete.

### 3.05 MAINTENANCE

- A. See Section 01 70 00 Execution Requirements, for additional requirements relating to maintenance service.
- B. Provide to Caesar Rodney School District, at no extra cost, a written maintenance contract for entire manufacturer's warranty period, to include the work described below.
- C. Perform routine inspection, testing, and preventive maintenance required by NFPA 72, including:
  - 1. Maintenance of fire safety interface and supervisory devices connected to fire alarm system.
  - 2. Repairs required, unless due to improper use, accidents, or negligence beyond the control of the maintenance contractor.
  - 3. Record keeping required by NFPA 72 and authorities having jurisdiction.
- D. Provide trouble call-back service upon notification by Caesar Rodney School District:
  - 1. Provide on-site response within 2 hours of notification.
  - 2. Include allowance for call-back service during normal working hours at no extra cost to Caesar Rodney School District.
  - 3. Caesar Rodney School District will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- E. Provide a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.
- F. Maintain a log at each fire alarm control unit, listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced. Submit duplicate of each log entry to Caesar Rodney School District's representative upon completion of site visit.
- G. Comply with Caesar Rodney School District's requirements for access to facility and security.

SECTION 312000 - EARTH MOVING

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Excavating and backfilling for buildings and structures.
  - 2. Drainage course for concrete slabs-on-grade.
- B. Related Sections:
  - 1. Section 015000 "Temporary Facilities and Controls" for temporary controls, utilities, and support facilities; also for temporary site fencing if not in another Section.
  - 2. Section 312319 "Dewatering" for lowering and disposing of ground water during construction.
  - 3. Section 315000 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.

#### 1.2 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
  - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
  - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
  - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
  - 2. Bulk Excavation: Excavation more than 10 feet (3 m) in width and more than 30 feet (9 m) in length.
  - 3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.

- H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. (0.76 cu. m) for bulk excavation or 3/4 cu. yd. (0.57 cu. m) for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
  - 1. Excavation of Footings, Trenches, and Pits: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch- (1065-mm-) wide, maximum, short-tip-radius rock bucket; rated at not less than 138-hp (103-kW) flywheel power with bucket-curling force of not less than 28,700 lbf (128 kN) and stick-crowd force of not less than 18,400 lbf (82 kN) with extra-long reach boom; measured according to SAE J-1179.
  - Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-hp (172-kW) flywheel power and developing a minimum of 47,992-lbf (213.3-kN) breakout force with a general-purpose bare bucket; measured according to SAE J-732.
- I. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. (0.57 cu. m) or more in volume that exceed a standard penetration resistance of 100 blows/2 inches (97 blows/50 mm) when tested by a geotechnical testing agency, according to ASTM D 1586.
- J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- K. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- L. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- M. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

## 1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
  - 1. Review geotechnical report.
  - 2. Review existing grades, utilities and subsurface conditions.
  - 3. Review coordination for interruption, shutoff, capping, and continuation of utility services.
  - 4. Review proposed excavations.
  - 5. Review proposed equipment.
  - 6. Review excavation support and protection systems.
  - 7. Review dewatering systems and requirements
  - 8. Review coordination with waterproofing.

## 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following manufactured products required:
  - 1. Geotextiles.
  - 2. Controlled low-strength material, including design mixture.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Material Test Reports: For each borrow soil material proposed for fill and backfill as follows:
  - 1. Classification according to ASTM D 2487.
  - 2. Laboratory compaction curve according to ASTM D 698.

#### 1.6 PROJECT CONDITIONS

- A. A "Table-Top" building site will be provided by others under separate contract.
- B. Existing Improvements: Protect existing building structures, site improvements and underground utility structures.
- C. Utility Locator Service: Notify "One Call" for area where Project is located before beginning earth moving operations.
- D. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures are in place. Erosion and sedimentation control measures are to be provided by others under separate contract.
- E. Do not commence earth moving operations until plant-protection measures specified in Section 015639 "Temporary Tree and Plant Protection" are in place.
- F. The following practices are prohibited within protection zones:
  - 1. Storage of construction materials, debris, or excavated material.
  - 2. Parking vehicles or equipment.
  - 3. Foot traffic.
  - 4. Erection of sheds or structures.
  - 5. Impoundment of water.
  - 6. Excavation or other digging unless otherwise indicated.
  - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- G. Do not direct vehicle or equipment exhaust towards protection zones.
- H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

### PART 2 - PRODUCTS

## 2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 4 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
  - 1. Minimum dry unit weight shall not be less than 105 PCF maximum dry density as determined by ASTM D-1557, modified proctor.

- C. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.
- D. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.
- E. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.
- F. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch (25-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.
- G. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.
- H. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and 0 to 5 percent passing a No. 4 (4.75-mm) sieve.
- I. Sand: ASTM C 33; fine aggregate.
- J. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

### 2.2 GEOTEXTILES

- A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
  - 1. Survivability: Class 2; AASHTO M 288.
  - 2. Grab Tensile Strength: 157 lbf (700 N); ASTM D 4632.
  - 3. Sewn Seam Strength: 142 lbf (630 N); ASTM D 4632.
  - 4. Tear Strength: 56 lbf (250 N); ASTM D 4533.
  - 5. Puncture Strength: 56 lbf (250 N); ASTM D 4833.
  - 6. Apparent Opening Size: No. 70 (0.212-mm) sieve, maximum; ASTM D 4751.
  - 7. Permittivity: 0.5 per second, minimum; ASTM D 4491.
  - 8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.
- B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
  - 1. Survivability: Class 2; AASHTO M 288.
  - 2. Grab Tensile Strength: 247 lbf (1100 N); ASTM D 4632.
  - 3. Sewn Seam Strength: 222 lbf (990 N); ASTM D 4632.
  - 4. Tear Strength: 90 lbf (400 N); ASTM D 4533.
  - 5. Puncture Strength: 90 lbf (400 N); ASTM D 4833.
  - 6. Apparent Opening Size: No. 60 (0.250-mm) sieve, maximum; ASTM D 4751.
  - 7. Permittivity: 0.02 per second, minimum; ASTM D 4491.
  - 8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

#### 2.3 CONTROLLED LOW-STRENGTH MATERIAL

- A. Controlled Low-Strength Material: Self-compacting[, flowable concrete material produced from the following:
  - 1. Portland Cement: ASTM C 150, Type I, Type II or Type III.
  - 2. Fly Ash: ASTM C 618, Class C or F.
  - 3. Normal-Weight Aggregate: ASTM C 33, 3/8-inch (10-mm) nominal maximum aggregate size.
  - 4. Foaming Agent: ASTM C 869.
  - 5. Water: ASTM C 94/C 94M.
  - 6. Air-Entraining Admixture: ASTM C 260.
- B. Produce conventional-weight, controlled low-strength material with 140-psi (965-kPa) compressive strength when tested according to ASTM C 495.

#### 2.4 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored as follows:
  - 1. Red: Electric.
  - 2. Yellow: Gas, oil, steam, and dangerous materials.
  - 3. Orange: Telephone and other communications.
  - 4. Blue: Water systems.
  - 5. Green: Sewer systems.
- B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored as follows:
  - 1. Red: Electric.
  - 2. Yellow: Gas, oil, steam, and dangerous materials.
  - 3. Orange: Telephone and other communications.
  - 4. Blue: Water systems.
  - 5. Green: Sewer systems.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

#### 3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
  - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

#### 3.3 EXPLOSIVES

- A. Explosives: Do not use explosives.
- 3.4 EXCAVATION, GENERAL

#### 3.5 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
  - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

### 3.6 EXCAVATION FOR UTILITY TRENCHES WITHIN BUILDING FOOTPRINT

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit unless otherwise indicated.
  - 1. Clearance: 12 inches (300 mm) each side of pipe or conduit.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
  - 1. For pipes and conduit less than 6 inches (150 mm) in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
  - 2. For pipes and conduit 6 inches (150 mm) or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
  - 3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
  - 4. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

- D. Trench Bottoms: Excavate trenches 4 inches (100 mm) deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
  - 1. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
  - 2. 015639 "Temporary Tree and Plant Protection."

### 3.7 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi (17.2 MPa), may be used when approved by Architect.
  - 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

### 3.8 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
  - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

#### 3.9 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
  - 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
  - 2. Surveying locations of underground utilities for Record Documents.
  - 3. Testing and inspecting underground utilities.
  - 4. Removing concrete formwork.
  - 5. Removing trash and debris.
  - 6. Removing temporary shoring and bracing, and sheeting.
  - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

## 3.10 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches (450 mm) of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete".
- D. Backfill voids with satisfactory soil while removing shoring and bracing.

- E. Place and compact initial backfill of subbase material, free of particles larger than 1 inch (25 mm) in any dimension, to a height of 12 inches (300 mm) over the pipe or conduit.
  - 1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- F. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches (300 mm) over the pipe or conduit. Coordinate backfilling with utilities testing.
- G. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- H. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.
- I. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.
- 3.11 SOIL FILL
  - A. Place and compact fill material in layers to required elevations as follows:
    - 1. Under steps and ramps, use engineered fill.
    - 2. Under building slabs, use engineered fill.
    - 3. Under footings and foundations, use engineered fill.
  - B. Place soil fill on subgrades free of mud, frost, snow, or ice.

### 3.12 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
  - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
  - 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

### 3.13 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
  - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches (300 mm) of existing subgrade and each layer of backfill or fill soil material at 95 percent.

2. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

#### 3.14 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
  - 1. Provide a smooth transition between adjacent existing grades and new grades.
  - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Grading inside Building Lines: Finish subgrade to a tolerance of 1/4 inch when tested with a 10-foot straightedge.

#### 3.15 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabson-grade as follows:
  - 1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
  - 2. Place drainage course 6 inches (150 mm) or less in compacted thickness in a single layer.
  - 3. Place drainage course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
  - 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

#### 3.16 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
  - 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
  - 2. Determine that fill material and maximum lift thickness comply with requirements.
  - 3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
  - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. (186 sq. m) or less of paved area or building slab, but in no case fewer than three tests.
  - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet (30 m) or less of wall length, but no fewer than two tests.
  - 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet (46 m) or less of trench length, but no fewer than two tests.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

## 3.17 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
  - 1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
  - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

## 3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.
- B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.
  - 1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

SECTION 312319 - DEWATERING

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes construction dewatering.
- B. Related Requirements:
  - 1. Section 312000 "Earth Moving" for excavating, backfilling, site grading, and controlling surface-water runoff and ponding.

#### 1.2 ACTION SUBMITTALS

- A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.
  - 1. Include plans, elevations, sections, and details.
  - 2. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
  - 3. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
  - 4. Include written plan for dewatering operations including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Field quality-control reports.
- C. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by dewatering operations. Submit before Work begins.
- D. Record Drawings: Identify locations and depths of capped wells and well points and other abandoned-in-place dewatering equipment.

#### 1.4 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.

#### 1.5 FIELD CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer

and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.

- 1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.
- 2. The geotechnical report is included elsewhere in Project Manual.

## PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
  - 1. Design dewatering system.
  - 2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
  - 3. Prevent surface water from entering excavations by grading, dikes, or other means.
  - 4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
  - 5. Remove dewatering system when no longer required for construction.
- B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water- and debris-disposal regulations of authorities having jurisdiction.

### PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
  - 1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.
  - 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- C. Provide temporary grading to facilitate dewatering and control of surface water.

#### 3.2 INSTALLATION

- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
  - 1. Space well points or wells at intervals required to provide sufficient dewatering.
  - 2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
- B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.
- C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
- D. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

#### 3.3 OPERATION

- A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.
- B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
  - 1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
  - 2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
  - 3. Maintain piezometric water level a minimum of 24 inches (600 mm) below bottom of excavation.
- C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.
- D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches (900 mm) below overlying construction.

#### 3.4 FIELD QUALITY CONTROL

- A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.
  - 1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
  - 2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
  - 3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

- B. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.
- C. Prepare reports of observations.

### 3.5 PROTECTION

- A. Protect and maintain dewatering system during dewatering operations.
- B. Promptly repair damages to adjacent facilities caused by dewatering.

## SECTION 313116 - TERMITE CONTROL

PART 1 - GENERAL

- 1.1 SUMMARY
  - A. Section Includes:
    - 1. Soil treatment with termiticide.
  - B. Related Sections:
    - 1. Section 061000 "Rough Carpentry" for wood preservative treatment by pressure process.
- 1.2 ACTION SUBMITTALS
  - A. Product Data: For each type of termite control product.
    - 1. Include the EPA-Registered Label for termiticide products.
- 1.3 INFORMATIONAL SUBMITTALS
  - A. Qualification Data: For qualified Installer.
  - B. Product Certificates: For termite control products, from manufacturer.
  - C. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:
    - 1. Date and time of application.
    - 2. Moisture content of soil before application.
    - 3. Termiticide brand name and manufacturer.
    - 4. Quantity of undiluted termiticide used.
    - 5. Dilutions, methods, volumes used, and rates of application.
    - 6. Areas of application.
    - 7. Water source for application.

#### 1.4 QUALITY ASSURANCE

- A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located.
- B. Regulatory Requirements: Formulate and apply termiticides and termiticide devices according to the EPA-Registered Label.
- C. Source Limitations: Obtain termite control products from single source.

### 1.5 PROJECT CONDITIONS

- A. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
- B. Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

#### 1.6 WARRANTY

- A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.
  - 1. Warranty Period: Five years from date of Substantial Completion.

#### 1.7 MAINTENANCE SERVICE

A. Continuing Service: Beginning at Substantial Completion, provide 24 months' continuing service including monitoring, inspection, and re-treatment for occurrences of termite activity. Provide a standard continuing service agreement. State services, obligations, conditions, terms for agreement period, and terms for future renewal options.

#### PART 2 - PRODUCTS

#### 2.1 SOIL TREATMENT

- A. Termiticide: Provide an EPA-Registered termiticide, complying with requirements of authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label.
  - 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. BASF Corporation, Agricultural Products; Termidor.
    - b. Bayer Environmental Science; Premise 75.
    - c. FMC Corporation, Agricultural Products Group; Dragnet FT.
    - d. Syngenta; Demon TC.
  - 2. Service Life of Treatment: Soil treatment termiticide that is effective for not less than five years against infestation of subterranean termites.

#### PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label requirements, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's written instructions for preparation before beginning application of termite control treatment. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.

- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.
  - 1. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

### 3.3 APPLICATION, GENERAL

- A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's EPA-Registered Label for products.
- 3.4 APPLYING SOIL TREATMENT
  - A. Application: Mix soil treatment termiticide solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of termiticide, according to manufacturer's EPA-Registered Label, to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction. Distribute treatment evenly.
    - 1. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
    - 2. Foundations: Adjacent soil, including soil along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing. Avoid soil washout around footings.
    - 3. Crawlspaces: Soil under and adjacent to foundations as previously indicated. Treat adjacent areas including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
    - 4. Masonry: Treat voids.
    - 5. Penetrations: At expansion joints, control joints, and areas where slabs will be penetrated.
  - B. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
  - C. Protect termiticide solution, dispersed in treated soils and fills, from being diluted until groundsupported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.
  - D. Post warning signs in areas of application.
  - E. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

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### SECTION 315000 - EXCAVATION SUPPORT AND PROTECTION

## PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes temporary excavation support and protection systems.
- B. Related Requirements:
  - 1. Section 312000 "Earth Moving" for excavating and backfilling and for controlling surfacewater runoff and ponding.
  - 2. Section 312319 "Dewatering" for dewatering excavations.

#### 1.2 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer.
- B. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.
- C. Shop Drawings: For excavation support and protection system, prepared by or under the supervision of a qualified professional engineer. Shop drawings shall be signed and sealed by the qualified professional engineer responsible for their preparation.

### 1.3 FIELD CONDITIONS

- A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
  - 1. Notify Owner no fewer than seven days in advance of proposed interruption of utility.
  - 2. Do not proceed with interruption of utility without Owner's written permission.
- B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from the data.
  - 1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection according to the performance requirements.
  - 2. The geotechnical report is included elsewhere in Project Manual.
- C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

### PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Provide, design, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting earth and hydrostatic pressures and superimposed and construction loads.
  - 1. Contractor Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer.
  - 2. Prevent surface water from entering excavations by grading, dikes, or other means.
  - 3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
  - 4. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

#### 2.2 MATERIALS

- A. General: Provide materials that are either new or in serviceable condition.
- B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.
- C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.
- D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application.
- E. Shotcrete: Comply with Section 033713 "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.
- F. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.
- G. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- H. Tiebacks: Steel bars, ASTM A 722/A 722M.
- I. Tiebacks: Steel strand, ASTM A 416/A 416M.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.
  - 1. Shore, support, and protect utilities encountered.
- B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

- 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- C. Locate excavation support and protection systems clear of permanent construction so that construction and finishing of other work is not impeded.

### 3.2 FIELD QUALITY CONTROL

- A. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.
- B. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

### 3.3 REMOVAL AND REPAIRS

- A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.
  - 1. Remove excavation support and protection systems to a minimum depth of 48 inches (1200 mm) below overlying construction and abandon remainder.
  - 2. Fill voids immediately with approved backfill compacted to density specified in Section 312000 "Earth Moving."
  - 3. Repair or replace, as approved by Architect, adjacent work damaged or displaced by removing excavation support and protection systems.