

STATE OF DELAWARE  
CAESAR RODNEY SCHOOL DISTRICT  
CONTRACT # SRS-18-012-NEWELEM

SPECIFICATIONS  
VOLUME 3

FOR

NEW CAESAR RODNEY ELEMENTARY SCHOOL

IN

Magnolia, Delaware

PREPARED  
BY



ARCHITECTURE  
ENGINEERING

Becker Morgan Group, Inc.

REBID DOCUMENTS  
November 30, 2018

## DOCUMENT 000101 - PROJECT TITLE PAGE

## 1.1 PROJECT MANUAL VOLUME 3

- A. New Caesar Rodney Elementary School.
- B. Magnolia, Delaware.
- C. Owner Project No. SRS-18-012-NEWELEM.
- D. Architect Project No. 2017073.00.
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- K. Issued: November 30, 2018.
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- 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, butt welded; 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, butt welded.
  - 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/#sle](http://www.lincolnmotors.com/#sle).
- B. A. O. Smith Electrical Products Company: [www.aosmithmotors.com/#sle](http://www.aosmithmotors.com/#sle).
- C. Reliance Electric/Rockwell Automation: [www.reliance.com](http://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.



- 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:
  - 1. 1200 rpm.
    - a. 1 hp:
      - 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.
- l. 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.
    - 3) Minimum Percent Efficiency: 92.
  - l. 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.
    - 2) Minimum Percent Power Factor: 88.

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

**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](http://www.isolationtech.com).
- B. Kinetics Noise Control, Inc: [www.kineticsnoise.com](http://www.kineticsnoise.com).
- C. Mason Industries: [www.mason-ind.com](http://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**

**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](http://www.bradycorp.com).
- B. Champion America, Inc: [www.Champion-America.com](http://www.Champion-America.com).
- C. Seton Identification Products: [www.seton.com/aec](http://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.

**END OF SECTION**



**SECTION 21 07 19**

**FIRE SUPPRESSION PIPING INSULATION**

**PART 2 PRODUCTS**

**1.01 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.

**END OF SECTION**

**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 Owner's insurance underwriter for approval.
  - 2. Submit proof of approval to Architect.
- 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.

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.

**END OF SECTION**

**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 Architect.
- 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 Owner'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 the State in which the Project is located.
- 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: Standard, Semi-recessed, Recessed or Concealed pendant type with matching push on, clamp on or screw on escutcheon plate.
  - 1. Finish: Brass or Chrome plated.
    - a. Within Standard Acoustical Tile Ceilings: White with White Escutcheon Plate
    - b. Within Wooden Finish Acoustical Clouds: Chrome Plated with Chrome Plated Escutcheon 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 and electric alarm, with pressure retard chamber and variable pressure trim; with test and drain valve.
- B. Flooding Deluge Valve: Gate type valve with rubber faced disc actuated manually with water motor alarm and electric alarm, with alarm testing trim.
- C. 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. 0.33 hp.
  - 2. 115 volts, single phase, 60 Hz.
- 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.

**END OF SECTION**



**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 Owner'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 the State in which the Project is located.
- 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.

**END OF SECTION**

**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/#sle](http://www.mercer-rubber.com/#sle).
  - 2. Metraflex Company: [www.metraflex.com/#sle](http://www.metraflex.com/#sle).
  - 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/#sle](http://www.mercer-rubber.com/#sle).
  - 2. Metraflex Company: [www.metraflex.com/#sle](http://www.metraflex.com/#sle).
  - 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.

**END OF SECTION**

**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](http://www.dwyer-inst.com).
  - 2. Venture Measurement, a Danaher Corporation Company: [www.venturemeasurement.com](http://www.venturemeasurement.com).
  - 3. Omega Meters: [www.omega.com](http://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:  $\pm 1\%$  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:  $\pm 1\%$
  - d. Response Time: 3 sec, 95% FS

## 2.02 PRESSURE GAGES

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  - 2. Moeller Instrument Co., Inc: [www.moellerinstrument.com/#sle](http://www.moellerinstrument.com/#sle).
  - 3. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).
- 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/#sle](http://www.dwyer-inst.com/#sle).
  - 2. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).



3. Weksler Glass Thermometer Corp: [www.wekslerglass.com/#sle](http://www.wekslerglass.com/#sle).
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.

**END OF SECTION**

**SECTION 22 05 48**

**VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT**

**SEE SPECIFICATION SECTION 23 05 48**

**END OF SECTION**

**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](http://www.bradycorp.com).
- B. Champion America, Inc: [www.Champion-America.com](http://www.Champion-America.com).
- C. Seton Identification Products: [www.seton.com/aec](http://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.

**END OF SECTION**

**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](http://www.knaufusa.com).
  - 2. Johns Manville Corporation; : [www.jm.com](http://www.jm.com).
  - 3. Owens Corning Corp; : [www.owenscorning.com/#sle](http://www.owenscorning.com/#sle).
  - 4. CertainTeed Corporation; : [www.certainteed.com](http://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](http://www.knaufusa.com).
  - 2. Johns Manville Corporation: [www.jm.com](http://www.jm.com).
  - 3. Owens Corning Corp: [www.owenscorning.com/#sle](http://www.owenscorning.com/#sle).
  - 4. CertainTeed Corporation; [www.certainteed.com](http://www.certainteed.com).
  - 5. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.



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/#sle](http://www.foamglasinsulation.com/#sle).
  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/#sle](http://www.armacell.com/#sle).
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C 534 Grade 3, Grade 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/#sle](http://www.jm.com/#sle).
    - 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.

**END OF SECTION**

**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](http://www.knaufusa.com).
  - 2. Johns Manville Corporation: [www.jm.com](http://www.jm.com).
  - 3. Owens Corning Corp: [www.owenscorning.com](http://www.owenscorning.com).
  - 4. CertainTeed Corporation; : [www.certainteed.com](http://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/#sle](http://www.foamglasinsulation.com/#sle).
  - 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/#sle](http://www.schundler.com/#sle).
- 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/#sle](http://www.armacell.com/#sle).
- 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/#sle](http://www.armacell.com/#sle).
  - 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/#sle](http://www.jm.com/#sle).
    - 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. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with PVC jacket and fitting covers.
- 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.
- 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 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, 1¼" 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.
  - 3. 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.
- 4. Field-Applied Jacket: Aluminum.
- 5. Vapor Retarder Required: Yes.
- 6. 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, Culvert Pipe and (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 (SDR-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 the Two-Step (Primer & Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
- 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.
- C. PVC Pipe: ASTM D2665 or ASTM D3034.
  - 1. Fittings: PVC.
  - 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

## **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](http://www.conbraco.com).
  2. Nibco, Inc: [www.nibco.com](http://www.nibco.com).
  3. Milwaukee Valve Company: [www.milwaukeevalve.com](http://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](http://www.conbraco.com).
  2. Nibco, Inc: [www.nibco.com](http://www.nibco.com).
  3. Milwaukee Valve Company: [www.milwaukeevalve.com](http://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](http://www.conbraco.com).
  2. Nibco, Inc: [www.nibco.com](http://www.nibco.com).
  3. Milwaukee Valve Company: [www.milwaukeevalve.com](http://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](http://www.conbraco.com).
  2. Nibco, Inc: [www.nibco.com](http://www.nibco.com).
  3. Milwaukee Valve Company: [www.milwaukeevalve.com](http://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](http://www.hammondvalve.com).
  2. Crane Co.: [www.cranevalve.com](http://www.cranevalve.com).
  3. Milwaukee Valve Company: [www.milwaukeevalve.com](http://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](http://www.bellgossett.com).
  2. Griswold Controls: [www.griswoldcontrols.com](http://www.griswoldcontrols.com).
  3. Taco, Inc: [www.taco-hvac.com](http://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](http://www.hammondvalve.com).
  2. Nibco, Inc: [www.nibco.com](http://www.nibco.com).
  3. Milwaukee Valve Company: [www.milwaukeevalve.com](http://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](http://www.hammondvalve.com).
  2. Crane Co.: [www.cranevalve.com](http://www.cranevalve.com).
  3. Milwaukee Valve Company: [www.milwaukeevalve.com](http://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/#sle](http://www.amtrol.com/#sle).
  2. Cla-Val Co: [www.cla-val.com/#sle](http://www.cla-val.com/#sle).
  3. Watts Regulator Company: [www.wattsregulator.com/#sle](http://www.wattsregulator.com/#sle).
- 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:
  1. MSS SP-85, cast iron body, bronze fitted, elastomeric diaphragm and seat disc, flanged.

## **2.25 RELIEF VALVES**

## **2.26 STRAINERS**

## **2.27 RELIEF VALVES**

- A. Pressure Relief:
  1. Manufacturers:
    - a. Cla-Val Co: [www.cla-val.com](http://www.cla-val.com).
    - b. Henry Technologies: [www.henrytech.com](http://www.henrytech.com).
    - c. Watts Regulator Company: [www.wattsregulator.com](http://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](http://www.cla-val.com).
    - b. Henry Technologies: [www.henrytech.com](http://www.henrytech.com).
    - c. Watts Regulator Company: [www.wattsregulator.com](http://www.wattsregulator.com).
  2. 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](http://www.armstronginternational.com).
  2. Green Country Filter Manufacturing: [www.greencountryfilter.com](http://www.greencountryfilter.com).
  3. WEAMCO: [www.weamco.com](http://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. All gas piping shall be painted standard ANSI yellow.
- B. Install in accordance with manufacturer's instructions.
- 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:
      - 1) Maximum hanger spacing: 10 ft.
      - 2) Hanger rod diameter: 1/2 inch.
    - d. Pipe size: 4 inches to 6 inches:
      - 1) 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":
    - 1) Maximum hanger spacing: 6 ft.
    - 2) Hanger rod diameter: 3/8 inch.
  - b. Pipe Size 8" and Over:
    - 1) Maximum hanger spacing: 6 ft.
    - 2) Hanger rod diameter: 7/8 inch.

**END OF SECTION**

**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 Owner'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/#sle](http://www.josam.com/#sle).
  - 2. Jay R. Smith Manufacturing Company: [www.jayrsmith.com](http://www.jayrsmith.com).
  - 3. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
  - 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/#sle](http://www.jayrsmith.com/#sle).
  2. Josam Company: [www.josam.com/#sle](http://www.josam.com/#sle).
  3. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
  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/#sle](http://www.arrowheadbrass.com/#sle).
  2. Jay R. Smith Manufacturing Company: [www.jayrsmith.com/#sle](http://www.jayrsmith.com/#sle).
  3. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
- 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/#sle](http://www.conbraco.com/#sle).
  2. Watts Regulator Company: [www.wattsregulator.com/#sle](http://www.wattsregulator.com/#sle).
  3. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
  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/#sle](http://www.conbraco.com/#sle).
  - 2. Watts Regulator Company: [www.wattsregulator.com/#sle](http://www.wattsregulator.com/#sle).
  - 3. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
  - 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/#sle](http://www.jayrsmith.com/#sle).
  - 2. Watts Regulator Company: [www.wattsregulator.com/#sle](http://www.wattsregulator.com/#sle).
  - 3. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
  - 4. Souix Chief Company.
  - 5. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Water Hammer Arrestors:
  - 1. 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](http://www.esbe.se/en).
    - b. Leonard Valve Company: [www.leonardvalve.com](http://www.leonardvalve.com).
    - c. Honeywell Water Controls: <http://yourhome.honeywell.com/#sle>.
    - 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**

## SECTION 221113 - FACILITY WATER DISTRIBUTION PIPING

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. This Section includes water-distribution piping and related components outside the building for water service and fire-service mains.
- B. Water distribution piping shall be installed to within five (5) feet of the edge of proposed building foundations, unless specifically noted elsewhere in the contract documents.
- C. Contractor shall furnish and install all mains, hydrants, valves and fittings as specified and indicated on the drawings.

## 1.3 OWNER, ARTESIAN AND CONTRACTOR, MATERIALS AND INSTALLATION COORDINATION

- A. Off-site Water Main Extension, from the connection point on north side of Briarbush Road to the project site:
  - 1. Materials will be purchased by Owner and provided by Artesian Water Company.
  - 2. Installation shall be completed by selected, Artesian Water Company approved, contractor under this contract.
  - 3. Selected contractor shall be approved by Artesian Water Company for water main installation.
- B. Fire Service Water Pipe, from connection located within R.O.W. to five (5) feet from edge of buildings:
  - 1. Materials shall be purchased under this contract except for the detector check  $\frac{3}{4}$  inch meter (7.5" assembly).
  - 2. Installation shall be completed by selected contractor under this contract.
  - 3. Transition from 6" dia water main to 8" diameter water main at approximately 10 linear feet downstream of meter vault.
- C. Domestic Water Service Assembly:
  - 1. Materials are identified in the contract drawings as 3" *CTS POLYETHYLENE WATER SERVICE ASSEMBLY DETAIL*.
  - 2. Materials shall be provided by Artesian Water Company.
  - 3. Installation shall be paid for and coordinated by Artesian Water Company.
  - 4. Installation contractor shall be approved by Artesian Water Company for water main installation.
- D. Domestic Water Service Pipe:
  - 1. Materials shall be purchased under this contract except for the domestic water meter(s).
  - 2. Domestic water meter shall be provided by Artesian Water Company.
  - 3. Installation shall be completed by selected contractor under this contract.



4. Domestic water service piping within meter vault shall be type K copper as detailed in this specification.

#### 1.4 SYSTEM PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure Ratings: Except where otherwise indicated, the following are minimum pressure requirements for water system piping.
  1. Underground Piping: 160 psi (1103 kPa).
  2. Underground Piping, Fire Suppression System: 200 psig (1380 kPa).
- B. Protection of Potable Water Supply:
  1. A minimum of 10 feet horizontal separation shall be provided between proposed water mains and proposed sewers.
  2. Clearances: Where specified crossing clearance cannot be obtained, sewer shall be encased in concrete for 10 feet each side of water main. For crossings of other utilities, sewer shall be encased with limits of the utility trench.
    - a. Sewer crossing water mains shall have a clearance of 18 inches below water main or shall be encased.
    - b. Sewers shall have a minimum of 6 inches clearance when crossing other utilities.

#### 1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
- C. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- D. Field quality-control test reports.
- E. Record drawings at Project closeout of installed water system piping and products according to Division 1 Section "Project Closeout."

#### 1.6 QUALITY ASSURANCE

- A. Regulatory Requirements:
  1. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
  2. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- C. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.
- D. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

- E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
- F. NSF Compliance:
  - 1. Comply with NSF 14 for plastic potable-water-service piping.
  - 2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.
- G. Provide listing/approval stamp, label, or other marking on equipment made to specified standards
- H. Off-site water main infrastructure shall comply with Artesian Water Company Standards.
- I. Water main infrastructure shall comply with Ten States Standards and State of Delaware Office of Drinking Water requirements.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
  - 1. Ensure that valves are dry and internally protected against rust and corrosion.
  - 2. Protect valves against damage to threaded ends and flange faces.
  - 3. Set valves in best position for handling. Set valves closed to prevent rattling.
- B. During Storage: Use precautions for valves, including fire hydrants, according to the following:
  - 1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
  - 2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.
- C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.
- D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
- F. Protect flanges, fittings, and specialties from moisture and dirt.
- G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

#### 1.8 PROJECT CONDITIONS

- A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
  - 1. Notify Construction Manager Owner & Municipality no fewer than five days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of water-distribution service without Construction Manager's & Municipality's written permission.

- B. Verify that water system piping may be installed in compliance with original design and referenced standards.
- C. Site Information: Reports on subsurface condition investigations made during the design of the Project are available for informational purposes only; data in reports are not intended as representations or warranties of accuracy or continuity of conditions (between soil borings). Owner and Architect assumes no responsibility for interpretations or conclusions drawn from this information

## 1.9 COORDINATION

- A. Coordinate connection to Building Plumbing and other Division 22 work.
- B. Coordinate with other utility work including but not limited to fire protection systems piping.
- C. Coordinate electrical requirements of actual equipment furnished with requirements specified in Division 26.
- D. Coordinate with identified contractor for Bid Pack 2.

## PART 2 - PRODUCTS

### 2.1 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, Class 50 cement-lined with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
  - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
  - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, Class 50 cement-lined with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
  - 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
  - 2. Gaskets: AWWA C111, rubber.
- C. Flanges: ASME 16.1, Class 125, cast iron.
- D. Comply with NFPA 24 and local/state regulations for fire-service mains.

### 2.2 PVC PIPE AND FITTINGS

- A. PVC, AWWA Pipe: AWWA C900, Pressure Class 235, DR 18 with bell end with gasket, and with spigot end.
- B. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
  - 1. Gaskets: AWWA C111, rubber.
- C. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

1. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Mains & Services for Fire Suppression

1. Comply with UL 1285 for fire-service mains if indicated.
2. Comply with NFPA 24 and local/state regulations for fire-service mains.

2.3 PE PIPE AND FITTINGS

- A. PE, AWWA Pipe: AWWA C901 & NSF Standard 14, DR 9 PE3608; with PE compound number required to give pressure rating not less than 200 psig.
- B. PE, AWWA Pipe: AWWA C906, ASTM F-714 and NSF Standard 14, DR No. 9 (200 psi) or DR No. 11 (160 psi).
  1. PE, AWWA Fittings: AWWA C906, butt-fusion type, with DR number matching pipe and PE compound number required to give pressure rating not less than adjoining piping.

2.4 COPPER PIPE

- A. Type K Copper Pipe, Standards ASTM B88, B306, B280, & B819, Compliance Certified For Use In Potable Water Applications, Max. Pressure Rated 435 psi.

2.5 PIPING SPECIALTIES

- A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- B. Split-Sleeve Pipe Couplings:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Romac Industries, Inc., 501 ductile iron coupling, or approved equal.
  2. Description: Metal, bolted, split-sleeve-type, reducing or transition coupling with sealing pad and closure plates, O-ring gaskets, and bolt fasteners.
    - a. Standard: AWWA C219.
    - b. Sleeve Material: Stainless steel.
    - c. Sleeve Dimensions: Of thickness and width required to provide pressure rating.
    - d. Gasket Material: O-rings made of EPDM rubber, unless otherwise indicated.
    - e. Pressure Rating: 200 psig minimum.
    - f. Metal Component Finish: Corrosion-resistant coating or material.

2.6 GATE VALVES

- A. AWWA, Cast-Iron Gate Valves:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Provide valves by Waterous, Mueller Co. or a comparable product approved by the Engineer.
2. Nonrising-Stem, Resilient-Seated Gate Valves:
  - a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.
    - 1) Standard: AWWA C509.
    - 2) Minimum Pressure Rating: 200 psig .
    - 3) End Connections: Mechanical joint.
    - 4) Interior Coating: Complying with AWWA C550.

## 2.7 GATE VALVE ACCESSORIES AND SPECIALTIES

### A. Tapping-Sleeve Assemblies:

1. Manufacturers: Provide products by one of the following:
2. Provide Mueller Co.; Water Products Div or a comparable product approved by the utility.
3. Description: Sleeve and valve compatible with drilling machine.
  - a. Standard: MSS SP-60.
  - b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
  - c. Valve: AWWA, cast-iron, nonrising-stem, resilient-seated gate valve with one raised face flange mating tapping-sleeve flange.

- ### B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, extra deep lid with two holes, adjustable extension of length required for depth of burial of valve (valve boxes shall be adjustable between 2'-4" and 3'-4" except when deeper settings are required) , plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel 5 1/4 inches in diameter.
1. Provide boxes by Mueller, or a comparable product approved by the utility.
  2. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.
  3. All boxes for 4, 6, and 8-inch valves shall be equipped with #6 round base. Valve boxes shall be adjustable between 2'-4" and 3'-4" except when deeper settings are required.

## 2.8 CORPORATION VALVES AND CURB VALVES

### A. Manufacturers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Ford Meter Box Company, Inc. (The); Pipe Products Div. model number per utility company standard.

- ### B. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.

1. Service Saddle: Stainless Steel with seal and AWWA C800, threaded outlet for corporation valve.
2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.

3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.
- C. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.
- D. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 4 1/4 inches in diameter.
1. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

## 2.9 FIRE HYDRANTS

### A. Dry-Barrel Fire Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. American Darling B-62-B or equivalent.
  - b. Substitutions shall be approved by the Architect.
2. Description:
  - a. Standard: AWWA C502.
  - b. All hydrants to be furnished with non-kinking chains on the 2 1/2-inch nozzles.
3. A sworn certificate of inspection and testing shall be furnished by the manufacturer. Install hydrants with restraint system as detailed on the drawings, or with a hydrant tee.

## 2.10 FIRE DEPARTMENT CONNECTIONS

### A. Fire Department Connections:

1. Manufacturers: Subject to compliance with requirements of the DE State Fire Marshal and local health department and match local fire department threads. Coordinate with Division 21.

## 2.11 IDENTIFICATION

- A. Metallic-Lined Plastic Underground Warning Tapes: Polyethylene plastic tape with metallic core, 6 inches (150 mm) wide by 4 mils (1 mm) thick, solid blue in color with continuously printed caption in black letters "CAUTION - WATER LINE BURIED BELOW."

## PART 3 - EXECUTION

### 3.1 EARTHWORK

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

### 3.2 PIPING APPLICATIONS

- A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

- B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.
- C. Do not use flanges or unions for underground piping.
- D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
- E. On-site Underground Water-Service and Fire-Service-service piping shall be any of the following:
  - 1. PVC, AWWA C900 Pressure Class 235 DR 18 pipe for fire-protection service; Ductile Iron fabricated fittings and gasketed joints.
  - 2. PE, AWWA C906 Pressure Class 160 SDR 11 Pipe for domestic water service as noted on the drawings.
  - 3. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products
  - 4. Installation shall be coordinated with and overseen by the fire protection contractor.
- F. Off-site Water Main Extension piping shall be:
  - 1. Ductile-Iron Pipe: AWWA C151, Class 50 cement-lined water pipe;
- G. Domestic water service meter vault piping shall be:
  - 1. Type K Copper, Standards ASTM B88, B306, B280, & B819, Compliance Certified For Use In Potable Water Applications, Max. Pressure Rated 435 psi.

### 3.3 VALVE APPLICATIONS

- A. General Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use threaded- or flanged-end valves for installation in vaults as indicated in utility company details. Use UL/FMG, non-rising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 and smaller installation.
- B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
  - 1. Underground Valves, NPS 3 and Larger: AWWA, cast-iron, nonrising-stem, resilient-seated gate valves with valve box.
  - 2. Use the following for valves in vaults and aboveground:
    - a. Gate Valves, NPS 3 and Larger: AWWA, cast iron, OS&Y rising stem, resilient seated.
  - 3. Relief Valves: Use for water-service piping in vaults and aboveground.

### 3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. General Locations and Arrangements: Drawings indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated except where deviations to layout are approved on coordination drawings.
- B. Install piping at indicated slope.

- C. Install restrained joints for buried piping within 5 feet (1.5m) of building. Use restrained-joint pipe and fittings, thrust blocks, anchors, tie-rods and clamps, and other supports at vertical and horizontal offsets.
- D. Install piping free of sags and bends.
- E. Locate groups of pipes parallel to each other, spaced to permit valve servicing.
- F. Install fittings for changes in direction and branch connections.

### 3.5 PIPING INSTALLATION

- A. Make connections NPS 2 and smaller with drilling machine according to the following:
  - 1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement as indicated on the drawings.
  - 2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
  - 3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
  - 4. Install corporation valves into service-saddle assemblies.
  - 5. Install manifold for multiple taps in water main.
  - 6. Install curb valve in water-service piping with head pointing up and with service box.
- B. Comply with NFPA 24 for fire-service-main piping materials and installation.
  - 1. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.
  - 2. Install copper tube and fittings according to CDA's "Copper Tube Handbook."
- C. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
  - 1. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.
- D. Install PVC, AWWA pipe according to ASTM F 645 and AWWA M23.
- E. Bury piping with depth of cover over top at least 42 inches, with top at least 12 inches below level of maximum frost penetration.
- F. Pipe cover can be temporarily reduced to 36 inches over the water pipe to clear another utility at a crossing with Owner approval.
- G. 8-inch diameter Tyton Push-Joint ductile-iron pipes can be deflected a maximum of 5 degrees or 19-inches per 18-foot pipe length vertically & horizontally (effectively a 205-foot radius without bends).
- H. A 2-inch blow-off is to be installed on the ends of mains.
- I. Installation shall comply with Ten States Standards, State of Delaware Office of Drinking Water requirements and Artesian Water Company Standards (for off-site water main extensions).
- J. Each section of pipe shall be placed on a solid foundation for its full length, with recesses excavated to accommodate the bell of the pipe. Any pipe which has its grade or joint disturbed after installation shall be removed and reinstalled. No pipe shall be installed on frozen or wet subgrade. Bedding material shall be provided, if required, by the Architect.
- K. The interior of the pipe shall be thoroughly cleaned of all foreign matter before being lowered into the trench, and shall be kept clean during laying operations by means of plugs or other approved methods.



Under no circumstances shall pipe be laid in water, and no pipe shall be laid when trench or weather conditions are unsuitable for such work.

- L. At all times work is not in progress, all open ends of pipe and fittings shall be securely closed so that no trench water, earth or other substance will enter the pipe or fittings.
- M. Any section of pipe in place and found to be defective shall be removed and replaced immediately at no cost to the Owner.
- N. No section of pipe shall be installed with deflection greater than manufacturer's recommendations either vertically or horizontally. Any deviation required to be greater than recommended shall be made with a special fitting.
- O. All installation of ductile iron pipe shall be in accordance with AWWA Standard No. C600 with detector tape.
- P. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
  - 1. Terminate water-service piping to within 5' of building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.
- Q. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.
- R. See Division 21 Section "Water-Based Fire-Suppression Systems" for fire-suppression-water piping inside the building.
- S. See Division 22 Section "Domestic Water Piping" for potable-water piping inside the building.

### 3.6 JOINT CONSTRUCTION

- A. Make pipe joints according to the following:
  - 1. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.
  - 2. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

### 3.7 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
  - 1. Concrete thrust blocks.
  - 2. Set-screw mechanical retainer glands.
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:
  - 1. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
  - 2. Fire-Service-Main Piping: According to NFPA 24.

- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

### 3.8 VALVE & VALVE BOX INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
- B. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.
- C. Valve boxes shall be installed at each outside valve. Boxes shall be sufficient length to provide a cover of not less than two feet over the pipe. Valve boxes shall be set plumb, and placed directly over the valve. Valve boxes shall be placed on two, 4-inch solid concrete blocks. After being correctly positioned, each fill shall be carefully tamped around the valve box for a distance of four (4) feet on all sides of the box. Any box found out of plumb or settled shall be reset at no cost to the Owner.

### 3.9 FIRE HYDRANT INSTALLATION

- A. General: Install each fire hydrant as required by the manufacturer's recommendations. Provide with separate gate valve in supply pipe, anchor. If no detail provided, use restrained joints or thrust blocks. Support hydrant in upright position.
- B. AWWA Fire Hydrants: Comply with AWWA M17.
- C. Hydrant leads shall be ductile iron.

### 3.10 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install protective pipe bollards as required by local fire marshal at each fire department connection. Pipe bollards are specified in Division 05 Section "Metal Fabrications."

### 3.11 FIELD QUALITY CONTROL

- A. Piping Tests: The Contractor shall furnish all equipment, labor, and materials, including water, pumps, compressors, stopwatch, gauges, and meters as approved by the Project Civil Architect for testing. The Project Civil Architect shall determine the amount of main to be tested at anyone time and reserves the right to separate the installation into several test sections. All tests must be witnessed by the Project Civil Architect or Owner.
- B. Domestic Water Main Hydrostatic Tests: Test at not less than one-and-one-half times working pressure or 100 psi, whichever is greater, for two hours.
  - 1. Test Pressure shall:
    - a. Be of at least two hour duration
    - b. Not vary by more than  $\pm$  five psi.
  - 2. Pressurization:
    - a. Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of the lowest point of the line or section under the test and corrected to the elevation of the test gauge shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Owner.
  - 3. Air Removal:

- a. Before applying the specified test pressure, air shall be expelled completely from the pipe, valves and hydrants. If permanent air vents are not located at all high points, the Contractor shall install corporation cocks at such points, so that the air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test, all corporation cocks shall be removed and plugged, or left in place at the discretion of the Owner.
4. Examination:
- a. All exposed pipe, fittings, valves, hydrants and joints shall be examined carefully during the test. Any damage or defective pipe, fittings, valves, or hydrants that are discovered following the pressure test shall be repaired or replaced with same material and the test shall be repeated until it is satisfactory to the Owner.
- C. Leakage Test: A leakage test shall be conducted concurrently with the pressure test.
- a. Leakage Defined: Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or at any valved section thereof, to maintain pressure within five psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water.
- b. Allowable Leakage: No pipe installation will be accepted if the leakage is greater than that determined by the following formula:

$$L = \frac{ND \text{ square root of } P}{7400}$$

in which L is the allowable leakage, in gallons per hour, N is the number of joints in the length of pipe line tested; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test in pounds per square inch gage.

Allowable leakage at various pressures is shown in Table I (appearing after this Subsection).

- c. When hydrants are in the test section, the test shall be made against the closed hydrant.
- d. Should the tests show the main to be defective, the Contractor shall remedy such defects and retest the main as specified above. This procedure shall be repeated until the test requirements are met.

**TABLE I**

Allowable Leakage per 100 feet of Pipeline* - gph						
Avg. Test Pressure psi	Nominal Pipe Diameter - Inch					
	2	3	4	6	8	10
150	0.19	0.28	0.37	0.55	0.74	0.92
125	0.17	0.25	0.34	0.50	0.67	0.84
100	0.15	0.23	0.30	0.45	0.60	0.75

*\*For pipe with 18-ft nominal lengths. To obtain the recommended allowable leakage for pipe with 20-ft nominal lengths, multiply the leakage calculated from the table by 0.9. If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.*

- D. Test fire suppression piping according to NFPA 24, as directed by the fire suppression contractor and local authorities
- E. Prepare reports of testing activities.

### 3.12 CLEANING

- A. Clean and disinfect water-distribution piping as follows:

1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
2. Use purging and disinfecting procedure prescribed the Delaware Department of Health. Procedure shall be as described in AWWA C651.
3. If method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
  - a. Upon completion of water main construction, disinfect main and appurtenances. Disinfection shall be done in accordance with ANSI/AWWA C-651, latest edition. Contractor shall submit a plan of disinfection for approval by the Architect.
  - b. After the applicable retention period, the heavily chlorinated water shall be flushed from the main. This water shall be discharged to the sanitary sewer system. Only after water leaving the main is no higher in chlorine concentration than normal drinking water, will a discharge to storm drains be allowed. Convey flushed water to discharge point in a closed system.
  - c. Affidavits of compliance, certifying the water sampled from the water mains to be free of coliform bacteria, shall be submitted to the Architect. The Contractor is responsible for requesting tests from the Delaware Department of Public Health. He shall provide written documentation when a section of mains can be placed in service.
  - d. The Contractor shall place in each length of pipe, hydrants, hydrant branches, and other appurtenances, a sufficient amount of HTH tablets to insure adequate disinfection treatment of the main after its completion. Tablets shall be fastened to the inside top of every length of pipe as laid, using gasket cement known as "Permatex No. 2".
  - e. The Contractor will be held entirely responsible for securing a minimum residual chlorine content of 5 p.p.m. at the extremities of the mains after twenty-four (24) hours or more contact with the full water pressure on the main.
  - f. Water for filling the mains shall be introduced at a velocity of less than one (1) foot per second in order to permit the HTH or Perchloron to completely dissolve and have a reasonable uniform distribution throughout the mains. It is the intent of this Specification to require a sufficient amount of chemical to be equivalent to a dosage of 50 p.p.m. of chlorine.
  - g. After the chlorine has been in contact with the mains or storage units for twenty-four (24) hours or longer, samples collected from the extremities of the mains shall indicate a residual chlorine content of 5 p.p.m. or more.

- h. If less than 5 p.p.m. residual chlorine is indicated, the system shall be drained and the disinfection treatment repeated.
    - i. If samples collected at the extremities indicate a residual chlorine of 5 p.p.m. or more, the system shall be flushed until there is only a normal chlorine residual (1.0 p.p.m. or less) present, as determined by the DPD Method Test. Samples of water shall be collected from various points along the lines, by a lab certified in the State of Delaware for bacteriological analysis. If satisfactory bacteriological results are obtained, the lines may then be allowed to be placed in service. A copy of all test results shall be submitted to the Architect.
  - 4. Contractor shall provide all disinfection testing within the lump sum prices bid.
- B. Prepare reports of purging and disinfecting activities.

END OF SECTION 221113

## SECTION 221313 - FACILITY SANITARY SEWERAGE

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. This Section includes gravity-flow, non-pressure sanitary sewerage outside the building and force-main pressure sanitary sewerage systems with the following components:
  - 1. Pipe line and trench excavation
  - 2. Precast concrete manholes
  - 3. Gravity Sewer Cleanouts
  - 4. Piping and fittings
  - 5. Miscellaneous materials
- B. All work performed on sanitary system components shall be performed by a contractor approved by the County and to the standards and specifications issued by the County including but not limited to Kent County Code, Chapter 180, Sanitary Standards.
- C. This section includes pressure force-main sanitary sewer system. This system includes all appurtenances to construct a complete, regulatory compliant and fully functioning force main conveyance system. This system shall include, but is not limited to, force main piping, air releases valve, flushing connection, directional drilled force main, valves, check valve and discharge connection to gravity sewer.
- D. This section includes non-pressure gravity sewerage system. This system includes all appurtenances to construct a complete, regulatory compliant and fully functioning gravity collection system, from building plumbing connection to the on-site sanitary sewerage pumping station. This system shall include, but is not limited to, building lateral connections, building cleanouts, sanitary sewer manholes, gravity sewer pipe and connection to on-site pump station.
- E. The Contractor shall furnish all materials and shall construct the pipe lines and all required appurtenances at the locations and to the lines, slopes and elevations shown on the drawings or designated by the Engineer.
- F. Manholes shall be built at such points on the pipe lines and of such form and dimensions as are shown on the drawings or as may be directed. Manholes shall be built as pipe laying progresses and the Engineer may stop work entirely on the laying pipe if manhole construction is delayed to such an extent as to be hazardous to construction or the public.
- G. The Contractor shall perform all excavation, dewatering, backfilling, directional drilling, test pit investigation, grubbing, grading, existing condition removal, existing condition replacement, full restoration, pavement replacement, required for construction and installation of pipelines, structures and appurtenances. Excavation shall include removal of pavement, concrete, rock, earth and debris, regardless of character. Trenches and excavations shall be sheeted, shored and braced by the Contractor, as necessary to allow construction and provide safe working conditions, additionally, the Contractor shall be responsible for maintaining a dry excavation by dewatering. He shall also locate, support and protect existing utilities and structures encountered in the work, provide traffic control, dispose of surplus and unsuitable excavated materials and restore backfilled areas to original condition or as required by the drawings and

specifications. All backfilled and restored areas shall be maintained by the Contractor, in a proper condition, for the duration of the project.

- H. The Contractor is responsible for direct or indirect damage to existing structures, pipelines, conduits, poles, wires and utilities of every description in the vicinity of his work whether above or below ground, or that may be encountered in trench or structure excavation. This responsibility shall include the cost of protection by sheeting, bracing, hand excavation, when warranted, and the expense to repair or replace any existing facility damaged directly or indirectly by construction activities under this contract, whether such facility is or is not shown on the drawings.
- I. The Contractor shall verify the location, size and elevation of all existing utilities at the various points of connection and/or crossings prior to starting any work. Any discrepancies in locations or elevations shall be brought to the attention of the Engineer in order that the designs may be adjusted accordingly. Damages suffered or additional costs incurred by the Contractor as a result of his failure to conform to the requirements of this paragraph shall be the sole responsibility of the Contractor. Connections to existing utilities shall be made by the Contractor at such a time and in such a manner as the Engineer may direct, and the cost shall be included in the price bid for pipeline and structures, unless otherwise defined in the proposal.
- J. Excavation and backfill, within an area where a State agency has jurisdiction, shall be done in accordance with requirements and provisions of the permits issued by the agencies for the construction within their respective rights-of-way. Such requirements and provisions, where applicable, shall take precedence and supersede the provisions of these specifications.

### 1.3 SUBMITTALS

- A. Product Data: For the following:
  - 1. Special pipe fittings.
- B. Shop Drawings: For the following:
  - 1. Manholes: Include plans, elevations, sections, details, and frames and covers.
  - 2. Gravity Sewer Cleanouts: Include fittings, frame, cover and appurtenances.
  - 3. Piping and fittings
  - 4. Pressure-type pipe couplings
  - 5. Valves
  - 6. Flushing Connection
  - 7. Air Release Valve
  - 8. Utility Marking Tape
  - 9. Pipeline Detector Wire
  - 10. The Contractor shall submit certifications to the Engineer that all pipe, fittings and joints are as specified herein.
- C. Field quality-control test reports.

### 1.4 QUALITY ASSURANCE

- A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to sanitary sewerage systems.
- B. Utility Compliance: Comply with local Municipality/utility company regulations and standards pertaining to sanitary sewer systems.

### 1.5 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle manholes according to manufacturer's written rigging instructions.

#### 1.6 PROJECT CONDITIONS

- A. Existing Utilities: Locate existing underground utilities in the areas of work. Call "Miss Utility" (1-800-282-8555) and the Kent County Department of Public Works for assistance in locating existing utilities. If utilities are to remain in place, provide adequate means of protection during construction of sanitary sewer system.
- B. If utilities are to remain in place, provide adequate means of protection during construction of sanitary sewer system.
- C. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to user unless permitted under the following conditions and then only after arranged to provide temporary service according to requirements indicated:
  - 1. Notify Engineer and the County no fewer than 5 days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of service without the Engineer's and the County's written permission.
- D. Should uncharted or incorrectly charted piping or other utilities be encountered during work, consult Owner immediately for directions as to procedure. Repair damaged utilities that are to remain in service to satisfaction of the associated jurisdiction.

### PART 2 - PRODUCTS

#### 2.1 EXCAVATION MATERIALS

- A. No classification of excavated materials will be made. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the contract work, regardless of the type, character, composition, or condition thereof.

#### 2.2 PRECAST REINFORCED CONCRETE MANHOLES

- A. Precast reinforced concrete risers, eccentric cones and bases shall be in conformance with ASTM C478. Joints between riser sections shall be fitted with an "O" ring rubber gasket, meeting the requirements of ASTM C443. Installation of risers shall be in accordance with manufacturer's recommendations under the supervision of the Engineer. Minimum compressive strength of concrete shall be 4000 psi in 28 days.
- B. Precast reinforced concrete base and riser sections shall be as manufactured by Atlantic Concrete Products Company, Virginia Precast Corporation, or equal.
- C. Interior and exterior joint spaces of all manhole risers shall be filled prior to application of the exterior waterproofing. The interior joint shall be mortared. The exterior joint may be mortared or filled with a joint filler compound. Said compound shall be Pioneer 301 as manufactured by Daubert Chemical Co., Oakbrook, Illinois, or equal.



- D. Lifting holes in the walls of precast reinforced concrete risers will be allowed but shall be plugged with rubber stoppers and grouted flush with face or manhole wall after the installation of manhole riser sections. Not more than two holes shall be cast in the walls of each riser section for the purpose of handling.
- E. The exterior surface of all precast manholes shall receive a minimum two coat application of a 68 percent solids coal tar type protective coating. The total average dry film thickness shall measure 24 mils with no single measurement to be less than 20 mils. Surfaces shall be prepared in accordance with the manufacturer's instructions and coatings applied in the field in a manner acceptable to the Engineer. The coating material shall be Bitumastic Super Service Black manufactured by Koppers Co., Inc., Pittsburgh, Pennsylvania, Tar-Jet Super Black XX-32-B-22 manufactured by Pennsbury Coatings Corp., New Britain, Pennsylvania, or equal.
- F. The interior surface of the force main doghouse manhole shall receive three coats of modified polyamide epoxy as manufactured by TNEMEC or Duraplate (100) Liner System (min. thickness of 140 mils).

### 2.3 FLOW CHANNELS

- A. All manhole flow channels and benches shall be constructed of brick with care taken to secure smooth and even surfaces with full mortar joints. Channel sections shall be built up to true line and radius, and curved sections shall provide a uniform transition in the flow direction.
- B. Materials and construction of flow channels shall be in accordance with appropriate sections for materials so used, as hereinafter specified.

### 2.4 CONCRETE

- A. All concrete for manhole base and cradles, encasements, blocking, etc. shall have a minimum compressive strength of 4,000 psi at 28 days.

### 2.5 BRICK

- A. All brick shall conform to the "Standard Specifications for Sewer Brick", ASTM C32, Grade SS except that the maximum absorption for the average of five bricks shall not exceed 10 percent; and the individual brick maximum shall not exceed 14 percent.

### 2.6 MORTAR

- A. Cement shall be in accordance with the "Standard Specifications for Portland Cement", ASTM C150 for Type II.
- B. Sand shall be composed of sharp, angular, silicious grains, coarse, or graded from fine to coarse with the coarsest grains predominating, and sensibly free from clay, loam, dirt, mica, organic matter, or other impurities. Sand containing more than 5 percent by weight of foreign material shall not be used. This limit may be changed for special classes of work if hereinafter specified. Sand exhibiting more than an acceptable amount of fine matter or impurities may be required to be washed after delivery on the work or shall be rejected altogether. Sand for mortar shall be screened to reject all particles of a greater diameter than 1/4-inch and shall not contain more than 5 percent by weight of a very fine material.
- C. Unless hereinafter specified otherwise, all mortar shall be composed of cement and sand of the character above specified. The proportion of volume shall be one part of cement to two of sand. One volume of cement shall be 94 pounds net. One volume of sand shall be 0.9 cubic feet, the sand not being packed more

closely than by throwing it into a box in the usual way. Mortar shall be fresh mixed in small batches for the work in hand. Tight boxes or platforms made for the purposes shall be used. The sand and cement shall be thoroughly mixed dry, in the proper proportions, until uniform color has been produced, whereupon a moderate dose of water shall be added, so as to produce a stiff paste of the proper consistency.

- D. Sand obtained from the excavation shall not be used.

## 2.7 MANHOLE STEPS

- A. Manhole steps shall be made of 3/8 inch diameter (No. 3) steel reinforcing bars, ASTM A615, Grade 60, encased in polypropylene plastic. Manhole steps shall have notched tread ridge with retainer lug on each side.
- B. Manhole steps shall be cast in place during manufacture of precast reinforced concrete manholes. Embedment length shall be suitable for minimum 5 inch thick, precast reinforced concrete riser walls.
- C. Manhole steps shall be OSHA approved and as manufactured by M.A. Industries, Inc., Peachtree City, Georgia, ICM, Inc., Jacksonville, Arkansas, or equal.
- D. Manhole steps shall be spaced twelve (12) inches apart. The maximum spacing from top of manhole to the first step shall not exceed sixteen (16) inches.

## 2.8 INSIDE DROP CONNECTIONS

- A. Manhole drop connections shall comply with Kent County Levy Court, Public Works Standards and Specifications.
- B. Inside drop shall be Reliner Inside Drop System, manufactured by Reliner / Duran Inc. of Lyme, CT. Contractor requested alternative products must be approved by Owner and Kent County Public Works prior to installation.
- C. Inside drop system shall be a plastic composite collection device that facilitates the controlled drop of effluent into the main stream flow of a sanitary manhole. The drop bowl permits easy inspection and cleaning without the need to enter the structure. The custom made adjustable stainless steel straps fully support the drop pipe.
- D. Drop bowl shall be fabricated from marine grade fiberglass. The clamping pipe supports are 304 stainless steel with 18-8 stainless nuts and bolts.
- E. Drop bowl shall be the "A" bowl with 6" outlet.
- F. Install with manufacture specific hardware kit.

## 2.9 MANHOLE FRAMES AND COVERS

- A. Frames and covers for manholes shall be set by the Contractor as the work progresses. The frame shall be well bedded in mortar.
- B. Material for frames and covers shall be in accordance with the standard specifications for gray iron castings ASTM A48 for Class No. 30.

- C. All frames and covers shall be of the sizes and types detailed on the drawings with "KENT COUNTY SANITARY SEWER" cast on the cover.

#### 2.10 CLEANOUT FRAME AND COVERS

- A. Frames and covers for lateral cleanouts shall be set by the Contractor as the work progresses. Three (3) foot diameter concrete donuts, one (1) foot inner diameter shall support frame and covers.
- B. Material for frames and covers shall be in accordance with the standard specifications for gray iron castings ASTM A48.
- C. Frame and cover shall meet Kent County Sewer Standards.

#### 2.11 DUCTILE IRON PIPE AND FITTINGS

- A. Ductile iron pipe for gravity sewer construction shall be Tyton Joint, Class 52 ductile iron pipe as manufactured by U.S. Pipe. All fittings shall be 250 PSI cast iron or 350 PSI ductile iron fittings per ANSI/AWWA requirements.
- B. Pipe and fittings shall have a 401 internal coating and external asphaltic coating approximately 1 mil thick.

#### 2.12 POLYVINYL CHLORIDE PIPE AND FITTINGS

- A. Polyvinyl chloride (PVC) pipe, used for sewer construction, shall equal or exceed the requirements of ASTM D 3034 and shall have a minimum standard dimension (SDR) ratio of 35 and the minimum pipe stiffness, as tested in accordance with ASTM D 2412, shall be 45 when measured under 5 percent deflection at 73 degrees Fahrenheit. Pipe shall be manufactured with integral wall bell and spigot joints in standard lengths not exceeding 20.0 feet.
- B. All fittings shall have a minimum SDR of 26.
- C. All polyvinyl chloride (PVC) pipe and fittings shall utilize an elastomeric O-ring gasketed joint assembled in accordance with the manufacturer's recommendations.
- D. Polyvinyl chloride wye branches, pipe stoppers and other fittings shall be manufactured in accordance with the same specifications and shall have the same thickness, depth of socket, and annular space as the pipe. Tee wye fittings will not be permitted for use. Wye branches shall be complete pipe sections. Saddles will not be permitted for use.
- E. Polyvinyl chloride pipe shall be delivered and stockpiled in unit pallets. Stacking of pallets above 5 feet in height will not be allowed. If pipe is stockpiled for more than 30 days prior to installation in the trench, it must be suitably covered with reflective material to protect the pipe from ultra-violet rays emanating from sunlight. Do not use plastic sheets. Allow for air circulation under covering.
- F. Bowed sections of pipe will be unacceptable and installation of pipe which has bowed, whether or not the bow has been corrected, will not be allowed on this project.

#### 2.13 HDPE PIPE AND FITTINGS

- A. High Density Polyethylene (HDPE) pipe, used for sewer transmission systems, shall equal or exceed the requirements of ASTM D3350 and ASTM D3035, with the cell classification of 445574C/E and is listed

with the Plastic Pipe Institute's (PPI) TR4. Pipe shall be made from PE 4710 resin. Pipe shall have a minimum standard dimension (SDR) ratio of 11. Pipe may be obtained in coiled or cut laying lengths.

- B. SDR 9 may be used for horizontal drilling installed pipe. Pipe shall be made from PE 4710 resin.
- C. All fittings shall have working pressures equal to or greater than connecting pipes. HDPE pipe is generally a continuous pipe from a long coil or lengths of pipe and fittings joined by thermal butt-fusion, electrofusion, or by special mechanical couplings. Joints for all HDPE pipe that is to be installed by horizontal directional drilling will be butt-fused. Butt-fusion and electrofusion joints are restrained joints and this should be considered in cases where sufficient lengths of pipe can be harnessed for use in thrust restraint in lieu of using concrete thrust blocking.
- D. Molded fittings according to ASTM D3261.
- E. Mechanical fittings used with HDPE pipe shall be specifically designed for, or tested and found to be acceptable for use with polyethylene pipe by the fitting manufacturer.
- F. Where sufficient length of restrained joint pipe is not available to restrain a fitting, provide thrust blocking.
- G. Special mechanical couplings and transition fittings are used for connecting HDPE pipe to HDPE pipe or to different pipe materials such as PVC in open-cut installation. Material and installation requirements for these special mechanical couplings and transition fittings shall follow manufacturer directions. Contractor shall confirm appropriate fittings and appurtenances are utilized.
- H. Some of the mechanical couplings provide joint restraint. HDPE has a very high coefficient of thermal expansion/contraction. To prevent pullout of the HDPE pipe from an unrestrained joint because of contraction due to change in temperature, a small thrust collar is installed on the HDPE pipe adjacent to the unrestrained joint.
- I. Where an HDPE pipe end is to be inserted into a mechanical type coupling or joint, a metal insert must be installed inside the end of the HDPE pipe that goes into the joint.

#### 2.14 AIR RELEASE STATION

- A. Air release station shall be manufactured by E-One, Model Number NC 0078G01 or approved equal.
- B. Contractor shall furnish complete factory-built and tested Combination Air Release Valve Station(s), each consisting of a stainless steel manifold for mounting a factory provided 2" Male NPT Combination Air Valve suitably mounted in an HDPE Tank. The tank and manifold shall feature a quick disconnect feature that enables the valve to be removed from the top of the tank (at grade level) without entering the tank, conforming to OSHA Confined Space Standards.
- C. Air release station shall be constructed to specifications and dimensions suitable for installation at depths, invert elevations and locations as shown in the contract drawings.
- D. The air release valve shall be a 2" Male NPT combination air valve that will act as an air release valve by allowing accumulated/entrapped air in the force main to escape as well as provide vacuum relief when needed. The valve shall include an inlet, outlet, body, cover, float and lever mechanism, orifice and seat. The valve shall be a single body standard combination valve designed specifically for sewage applications.
- E. The tank shall be an open bottom wetwell design made of high density polyethylene of a grade selected for environmental stress cracking resistance. Corrugated sections are to be made of a double wall construction with the internal wall being generally smooth. Corrugations of the outside wall are to be of a minimum amplitude of 1-1/2" to provide necessary transverse stiffness. Any incidental sections of a single wall

construction are to be a minimum .250 inch thick. All seams created during tank construction are to be thermally welded and factory tested for leak tightness. Tank wall must withstand the pressure exerted by saturated soil loading at maximum burial depth. All station components must function normally when exposed to maximum external soil and hydrostatic pressure.

- F. The tank shall include a lockable cover assembly providing low profile mounting, watertight and insulated capability. The cover shall be high density polyethylene, green in color, with a load rating of 150 lbs per square foot. The cover assembly shall also include an integral 2-inch vent to prevent sewage gases from accumulating in the tank. The accessway design and construction shall facilitate field adjustment of station height in increments of 3" or less without the use of any adhesives or sealants requiring cure time before installation can be completed.
- G. All valve manifold fittings and piping shall be constructed from 304 Stainless steel and shall be factory assembled. The valve inlet manifold shall also include a 1/4" stainless steel bleed off valve for ease of service. The tank shall include a 1-1/4" stainless steel ball valve rated for 235 psi WOG with a quick disconnect feature to simplify installation and valve removal. The bulkhead penetration of this valve shall be factory installed and warranted by the manufacturer to be watertight and shall terminate outside the accessway bulkhead with a stainless steel, 1-1/4" female NPT fitting. PVC ball valves or brass ball/gate valves will not be accepted.

## 2.15 MICELLANEOUS MATERIALS

- A. Polyethylene Sheeting: ASTM D 4397, with at least 8-mil thickness.
- B. Detectable pipeline wire: Insulated (green color) solid copper, #14 AWG, 600 volt, of not less than 90% conductivity, conforming to ASTM Designation B.58. Splicing of wires shall be by a solderless, split-bolt lug connector, Type IK-8, by ILSCO or equal.

## PART 3 - EXECUTION

### 3.1 PIPELINE TRENCH EXCAVATION

- A. The Contractor shall excavate, maintain and backfill all excavation necessary for completing the work under the contract. Unless otherwise specified or approved, excavation shall be open cut. No extra compensation will be allowed for hand excavation and backfill necessary to complete the work or required by the Engineer.
- B. Trenches shall be excavated to the necessary width and depth, as shown on the drawings and as required for the protective sheeting, pull boxes, etc. No extra compensation will be allowed for trenches wider than that detailed on the drawings.
- C. The sides of the trenches shall be practically plumb and shall not be sloped unless approved in writing by the Engineer. Trench sides shall be supported or sheeted as required to protect utilities, etc., and required for safety. Safety regulations shall be as required by state safety codes and OSHA.
- D. In non-paved areas strip surface vegetation and topsoil and place in stock piles which are separated from the trench excavated materials. Topsoil shall not be used for general trench refill.
- E. The excavation of all trenches shall be fully completed at least twenty (20) feet in advance of pipe laying, unless otherwise authorized or directed. The Engineer may require the backfilling of open trench, over completed pipelines, or ahead of the pipe laying operation, if in his judgement such action is necessary, and the Contractor shall have no claim for extra compensation.

- F. Should work be stopped for any reason and any excavation is left open for an unreasonable length of time, the Contractor shall refill the excavation at his own expense if so directed, by the Engineer or the DOH Inspector. He shall not reopen the excavation until he is ready to complete the facility. Should the Contractor refuse or fail to refill any excavation completely within forty-eight (48) hours or immediately if it poses a safety hazard after a proper notice, has been given by the Engineer or DOH Inspector the Owner shall be authorized to do the work. The resulting expenses shall be deducted from monies due the Contractor.
- G. The Contractor shall complete excavation as nearly as practicable to the lines of the pipeline to be installed as detailed. All cavities in the bottom of the trench shall be filled to the required level with compacted crushed stone or gravel.
- H. Excavated materials shall be graded, hauled, stored and protected as such material found suitable will be required for backfilling, repaving or other purposes. Material classified as unsuitable shall be disposed of by the Contractor at a location approved by the Engineer. Hauling of excavated materials for any purpose shall not entitle the Contractor to additional compensation. Only those excavated materials designated by the Owner shall become property of the Contractor.
- I. All stockpiled materials shall be placed in such a way to prevent damage to the trench, structures, drainage areas or private property. Excavated materials shall not be placed on private property unless a temporary easement agreement is obtained from the property Owner by the Contractor.
- J. The Contractor shall remove, relocate, change or protect all structures including but not limited to signs, mailboxes, overhead and buried utilities as required for construction whether shown on drawings or not. No extra compensation will be allowed for property damage, injury or loss of time due to obstructions encountered not shown on plans.
- K. The Contractor shall be responsible for any damage to curb, gutter, sidewalk, traffic control devices, pavement material and lawns. Any damage resulting directly or indirectly shall be replaced in kind by the Contractor without additional compensation. The reuse of disturbed curb, gutter or sidewalk is prohibited. New sections shall be installed to the nearest undisturbed control joint.

### 3.2 PIPELINE TRENCH BACKFILL

- A. Materials excavated from the trench except topsoil shall be used for trench backfill, provided that, in the opinion of the Engineer, the excavated material is suitable for this purpose. Backfill material shall be free from large lumps, pavement, pieces of concrete and stones.
- B. Suitable material, as approved by the Engineer, shall be carefully deposited in the trench by methods which will not damage or disturb the pipeline or structure, and shall be solidly tamped around the pipe or structure. Backfill material shall be placed in 8-inch layers. Compaction shall be accomplished by mechanical tampers. Care shall be taken in the use of mechanical tampers not to injure or move the pipe or to cause the pipe to be supported unevenly. Each layer shall be mechanically tamped for the full trench width unless an alternative method is approved in writing by the Engineer.
- C. Every backfill layer shall be compacted to 95% of maximum density at optimum moisture content as determined by the Modified Proctor Test, ASTM D1557 Method C. Materials containing an excess of moisture shall be permitted to dry until the moisture content is within the specified range. Materials too dry shall be wetted uniformly until the moisture content is in the specified range. Backfilled trench sections which fail to meet density requirements three consecutive times shall be excavated and properly disposed of by the Contractor.
- D. No compacting shall be done when the material is too wet to be compacted properly. At such times the work shall be suspended until the backfill materials have dried sufficiently to permit proper compaction or

such other precautions shall be taken as may be necessary to obtain proper compaction. The Contractor is responsible for hauling, storing and drying of excavated material to be used in backfill operations within the prices bid.

- E. The Engineer may request compaction tests of the backfilled trenches at any time during construction or upon completion of the backfill operations. Field density testing may be performed at a rate of 1 test per 100 linear feet of trench, at a depth specified by the Engineer. Such testing shall be arranged by the Contractor and performed by an independent testing agency approved by the Engineer. The Contractor shall pay the testing laboratory for all tests performed inclusive of sample collection, preparation and transportation.
- F. Whenever test results indicate compaction densities less than specified, the Contractor shall, at his own expense, secure the specified compaction using methods approved by the Engineer. The testing agency, so employed by the Contractor, shall submit a copy of all testing reports directly to the Engineer. Each report shall contain the project identification name and number, name of Contractor, name of testing agency, and location of sample tested by station, street and depth, as a minimum.
- G. The Contractor shall, at his own expense, maintain all refilled excavations in proper condition. Trench surfaces shall be reshaped when necessary. If the Contractor fails to make repairs within forty eight (48) hours after receipt of written notice from the Owner, the Owner may refill said depression wherever necessary and the cost of so doing will be retained from any monies due or to become due the Contractor under the Contract. The Contractor shall be fully responsible for any injury or damage that may result from lack of maintenance of any refilled excavation at any time prior to final acceptance.
- H. All unauthorized excavations made by the Contractor shall be immediately backfilled in accordance with the requirements of the specifications for trench backfill at the Contractor's expense.
- I. After completion of backfilling, all material not used shall be disposed of as approved by the Engineer, and all places on the line of the work shall be left clean and in good condition. This cleaning up shall be done by the Contractor without extra compensation. If he fails to do this work within a reasonable time after receipt of notice, it will be performed by the Owner, and the cost will be retained from the monies due the Contractor under the contract.
- J. No backfilling of pipelines will be allowed until measurements of pipe and an inspection has been performed by the Owner's representative, and until the Engineer has authorized the backfill. Any unauthorized backfill of pipelines shall be uncovered by the Contractor at his expense if required by the Engineer.

### 3.3 EXCAVATION FOR STRUCTURES

- A. Excavate for structures, walls, foundations, footings, etc., to the depth and width required for construction and stripping of forms. Structural excavation shall consist of the excavation of all earth, rock boulders, existing concrete and masonry foundations and walls, and all other materials encountered regardless of type, which the Contractor may encounter.
- B. Excavated materials shall be segregated as they are excavated, with the suitable and unsuitable material and topsoil being piled separately. All suitable material shall be used for backfill. All unsuitable material shall be removed, at the Contractor's expense, and disposed of at a location approved by the Engineer. No excavated material shall be deposited at any time so as to endanger partly finished structures either by direct pressure, or indirectly by overloading banks contiguous to the operation.
- C. The Contractor shall be responsible for the condition of all excavations made by him. All slides and cave-ins shall be removed without extra compensation, at whatever time and under whatever circumstances they may occur.

- D. All provisions of the sub-section "Pipeline Trench Excavation" which apply to "Excavation for Structures" shall be included under this section.

### 3.4 BACKFILL FOR STRUCTURES

- A. Backfill around structures with suitable material from the excavation to the original surface grades or the finished grades shown on the plans or defined by the Engineer.
- B. No backfill shall be placed against new concrete or masonry structures until properly cured.
- C. Backfill shall be placed in six (6) inch layers and compacted by mechanical tampers. Compaction shall conform with the requirements for compaction already set forth in this specification.
- D. The Contractor shall exercise caution in backfill and compaction to prevent damage to structures.

### 3.5 DEWATERING

- A. All excavations must be kept free of water below the subgrade of the work while work is in progress. This may be accomplished by ordinary pumping methods or by well points, whichever will produce the required results. Upon removal of dewatering equipment, the Contractor shall backfill all holes and restore disturbed areas to their original condition.
- B. Dewatering for the structures and pipelines shall commence when groundwater is first encountered and shall be continued until such time as backfill has been completed. No concrete or pipe shall be laid in water nor shall water be allowed to rise over them until the concrete or mortar has set at least eight (8) hours. Groundwater shall not be allowed to rise around the pipe until the trench is backfilled.
- C. The Contractor shall dispose of the water from the work in a suitable manner without damage to adjacent property. No water shall be drained into work built or under construction without prior consent of the Engineer. Water shall be disposed of in such a manner as not to damage property or be a menace to the Public Health.
- D. In the event the Contractor's dewatering operations affect any water supplies within the project area, the Contractor shall take whatever steps that are required to provide uninterrupted water service.
- E. The Contractor shall remove any siltation deposits in storm sewer systems, resulting from his dewatering or construction operations. He shall also be responsible for conveyance of dewatering flows and for erosion and sediment control.

### 3.6 SHEETING, SHORING AND BRACING

- A. The contractor shall furnish and install all sheeting, shoring and bracing necessary to insure safe working conditions and to prevent damage to public and private property and structures. If, in the opinion of the Engineer, the sheeting, shoring, or bracing is not of proper quality or is not properly placed to insure safe working conditions and to prevent property damage, the Contractor shall remedy such inadequacy at his own expense as may be directed by the Engineer. Sheeting, shoring, and bracing shall be removed as backfilling progresses, except at such locations as the Engineer may direct or approve it to be left in place.
- B. The condition of all excavations made by the Contractor shall be the responsibility of the Contractor. No extra compensation will be allowed for property damage, injury or loss of time, due to excavation slides or cave-ins at any time under any circumstances.



- C. The Contractor shall cut off any sheeting left in place, at least eighteen (18) inches below finished grade, and shall remove the material cut off without compensation.
- D. Where necessary, in quicksand, soft ground, or for the protection of any structure or property, sheeting shall be driven to such depth below the bottom of the trench as may be required to protect all existing and/or proposed work.
- E. The cost for furnishing, placing and removal of sheeting, shoring or bracing shall be included in the prices bid.
- F. A trench box is an acceptable alternative to sheeting, shoring or bracing providing such boxes conform to safety codes.

### 3.7 SELECT BACKFILL

- A. Should the Contractor encounter unsuitable material during excavation, he shall remove and dispose of such material at a location approved by the Engineer. The cost of such disposal shall be included in the prices bid for pipe and structures. Contractor shall notify Owner that material must be taken off site. No excavated soil may be removed from the site without the Owners written permission.
- B. Should sufficient suitable material from excavations on the project not be available for backfill, the Contractor shall furnish Select Backfill upon approval of the Engineer. Special backfill shall conform to Delaware Department of Transportation Standard Specifications.

### 3.8 LAYING BRICK

- A. All brickwork shall be laid by competent mechanics.
- B. All brick shall be laid in a full bed of mortar with all vertical and horizontal joints filled solid with mortar.
- C. Joints shall be not less than 3/8-inch or more than 1/2-inch wide except as otherwise specified in (E) below.
- D. No brickwork shall be laid when the temperature is below 40 degrees or when the indications are for lower temperature within 24 hours. The contractor shall take such measures as may be approved to prevent brickwork from being exposed to freezing temperatures for a period of not less than five days after laying.
- E. Special care shall be taken in laying brick in inverts of manholes to insure a uniform flow of water through the sections. In such locations, joints shall not exceed 1/16-inch in thickness and each brick shall be laid in full mortar bed with joints on bottom side and end made in one operation. No grouting or working in of mortar after laying the brick will be permitted.

### 3.9 MANHOLE TESTS

- A. If inspection reveals any visible leakage or seepage in any manhole, the contractor will be required to accomplish such remedial measures as may be directed by the Engineer. Caulking or patching of interior manhole surfaces will not be acceptable.

### 3.10 PIPE INSTALLATION

- A. Pipe and fittings shall be carefully handled and lowered into the trench. Special care shall be taken to insure that each length shall abut against the next in such a manner that there shall be no shoulder or unevenness of any kind along the inside of the pipe.
- B. Before pipe is placed, the bottom of the trench shall be carefully shaped to fit the lower part of the pipe exterior with reasonable closeness for width of at least 60% of the pipe width. Bell holes shall be dug sufficiently large to insure the making of proper joints and so that after placement, only the barrel of the pipe receives bearing pressure from the trench bottom. No pipe shall be brought into position until the preceding length has been thoroughly bedded and secure in place. Any defects due to settlement shall be made good by the Contractor without additional compensation therefore.
- C. Proper and suitable tools and appliances for the safe and convenient handling and laying of pipe shall be used.
- D. Whenever a pipe requires cutting to fit into the line or to bring it to the required location, the work shall be done in a satisfactory manner so as to leave a smooth end.
- E. The pipes shall be thoroughly cleaned before they are laid and shall be kept clean until the acceptance of the completed work. The open ends of all pipe lines shall be provided with a stopper carefully fitted so as to keep dirt and other substances from entering. This stopper shall be kept in the end of the pipe line at all times when laying is not in actual progress.
- F. All concrete required to support and reinforce wye branches, bends and other fittings shall be placed as directed, and the cost thereof shall be included and covered within the price bid.
- G. Backfill materials shall be hand placed and mechanically tamped in six inch layers, placed uniformly on both sides of the pipe, to a point at least one foot above the pipe crown. Each layer shall be thoroughly compacted for the full trench width and under, around and over the pipe.
- H. Pipeline detectable tape shall be installed continuously along all sewer mains. The tape shall be installed directly above the pipe and 12 inches from the ground surface. The tape shall be Lineguard type III Detectable tape as manufactured by Lineguard, Inc. of Wheaton, Illinois or equal. The tape shall be a minimum of two inches wide, imprinted in green with the words "CAUTION -- SEWER LINE BELOW" and be capable of being detected with inductive methods.
- I. Sewer force main shall be installed along the horizontal and vertical alignment depicted in the contract documents.
- J. Minimum radius of curvature for HDPE pipe installed in open-cut trench is forty (40) times the outside pipe diameter. Minimum radius of curvature for directionally drilled HDPE is dependent on allowable radius of curvature of Contractors' drilling rods. For design purposes, this can be assumed to be forty (40) feet. Radius of curvature at low points should be maximized.
- K. Do not design ninety (90°) degree bends in the force main pipeline alignment.
- L. To install HDPE pipe by horizontal directional drilling construction areas will be required at one end of the operation for layout and fusing pipe lengths to be pulled unless coils are used, and at the other end to set up and operate the drilling/pulling machine and drilling fluid storage tank and waste fluid storage. The amount of area required depends on the specific equipment used. Generally, sufficient area will be available in the normal right-of-way and construction strip used in the pipeline design. Verify that adequate space is available in the right-of-way and construction limits.
- M. For refill of the remaining trench depth, refer to "Excavation and Backfill" Section of these specifications.

## 3.11 LAYING PIPE IN FREEZING WEATHER

- A. No pipe shall be laid upon a foundation into which frost has penetrated, nor at any time when the Engineer shall deem that there is danger of the formation of ice or the penetration of frost at the bottom of the excavation unless all required precautions as to the minimum length of open trench and promptness of backfilling are observed.

## 3.12 ARTIFICIAL FOUNDATION

- A. Whenever directed, the Contractor shall lay pipe upon an artificial foundation which he shall construct. Such foundation may consist of gravel, sills, planks, or other timber construction, or of concrete; all to be of the form and dimensions and placed in the manner required by the Engineer.

## 3.13 PIPE TESTING

## A. GENERAL

- 1. Contractor shall furnish all labor, tools, materials, and equipment, including mirrors, flashlights or other artificial lighting, pump, compressors, stopwatch, gauges, and meters, subject to the approval of the Engineer for testing in accordance with these specifications.

## B. MIRROR TESTING OF SANITARY SEWERS

- 1. Upon completion of pipe laying and backfilling to a point at least two (2) feet above the crown of the pipe, the Engineer will conduct a mirror test to check for defects, excess deflection, leakage, and for horizontal or vertical misalignment. Mirror testing shall consist of reflecting sunlight or artificial light via mirrors through the completed section of pipeline, which, in order to be accepted, shall be true and straight in horizontal and vertical alignment to allow for the full passage of the reflected light.

## C. LEAK TESTING USING AIR

- 1. Sewers shall be tested in sections not exceeding 400 feet unless otherwise approved by the Engineer. Each section shall be tested immediately upon completion thereof. Each section shall meet the air pressure drop limitations specified herein.
- 2. All material and labor required for leakage tests shall be furnished by the Contractor within the price bid.
- 3. Sewers shall be tested using the low-pressure air method in accordance with the requirements of ASTM C-828 and the Uni-Bell Plastic Pipe Association recommendations, based upon the Ramseyer test time criteria. Procedural and equipment details shall be submitted to the Engineer prior to acceptance of its use for testing.
- 4. If the test time for the designated size and length, elapses before the test pressure drops 0.5 psig, the section undergoing the test shall have passed.
- 5. If the pressure drops 0.5 psig before the appropriate test time has elapsed, the air loss rate shall be considered excessive and the section of pipe has failed the test. Contractor shall determine at his own expense the source or sources of leakage and he shall repair or replace all defective materials and/or workmanship to the satisfaction of the Engineer. The completed pipe installation shall then be retested and required to meet the requirements of this test.

**D. MANDREL TESTING OF SANITARY SEWERS**

1. Sanitary sewer pipe shall be deflection tested not less than 30 days after the trench backfill and compaction has been completed. The test shall be conducted by pulling an approved solid pointed mandrel through the completed pipeline. The diameter of the mandrel shall be 95 percent of the inside diameter of the pipe. The mandrel shall be a rigid, non-adjustable mandrel having an effective length of not less than its nominal diameter.
2. Testing shall be conducted on a manhole to manhole basis and shall be done after the line has been completely cleaned and flushed. Any portion of the sewer which fails to pass the test shall be excavated, repaired or realigned and retested with both air and deflection tests.

**E. TESTING AND ACCEPTANCE - FORCE MAIN**

1. Test all new force mains before connecting them to the existing system. The Engineer shall determine the amount of main to be tested at any one time and reserves the right to separate the installation into several sections, in the event of long extensions, installations of pipe designed for different head conditions, or for other reasons.
2. Hydrostatically test the pipe at a pressure 1.5 times the normal working pressure with a minimum pressure of 100 psi. Hold the test pressure for a period of at least two (2) hours during which time the test pressure shall not vary more than  $\pm 5$  psi.
3. Fill each valved section of pipe with water slowly and apply the specified test pressure, based on the elevation of the lowest point of the line or section under test, corrected to the elevation of the test gauge, by means of a pump connected to the pipe in a manner satisfactory to the Engineer.
4. Expel air completely from the pipe and valves before applying the specified test pressure. If permanent air vents are not located at all high points, install corporation cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, close the corporation cocks and apply the test pressure. At the conclusion of the pressure test, remove the corporation cocks and plug the openings, or leave in place at the discretion of the Engineer.
5. Conduct a leakage test concurrently with the pressure test. Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain the pressure within 5 psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water. Allowable leakage for 1.25 inch nominal pipe diameter is 0.0975 gallons per hour per 1,000 linear feet of pipeline.
6. Acceptance shall be determined on the basis of allowable leakage as specified above. If any test of pipe laid discloses leakage greater than specified, the Contractor shall, at his own expense, locate and repair the defective material until the leakage is within the specified allowance. Repair all visible leaks regardless of the amount of leakage.

**3.14 DEFECTS TO BE MADE GOOD**

- A. If, at any time before the expiration of the guarantee period under this contract, any broken pipe, or any other defects are found in any of the lines or in any of the appurtenances, the Contractor shall cause the same to be removed and replaced by the proper material and workmanship, without extra compensation for the labor and material required, even though such injury or damage may not have been due to any act, default, or negligence on the part of the Contractor. All materials shall be carefully examined by the Contractor for defects prior to installation, and any found defective shall be rejected for use.

## 3.15 SITE RESTORATION

- A. Restore all areas, structures, plants, pavements, facilities, and features to not less than the pre-existing conditions.
- B. Restore areas outside of pavement at a uniform rate closely following installation of the pipeline. Neatly dress the area within one week following backfilling operations. Dress again or permanently restore when the soil has consolidated. Restoration of surfaces shall be completed within fifteen (15) days after the installation of the pipeline.
- C. Replace small trees and shrubs in kind at no additional cost to the Owner in the event that existing plants which are to remain are destroyed beyond use.
- D. Water all trees and shrubs as necessary to maintain the plantings until established.
- E. Mulch trees, shrubs, and ground cover with at least a 2" cover of mulch. Place mulch on the same day of planting. Wrap all trees with the wrapping material overlapping 1-1/2" from the lowest main branches to the base of the tree. Tie the wrapping at the top and bottom, and at 1' intervals along the trunk with twine.
- F. Topsoil, seed, and mulch non-paved areas in accordance with Division 2 Section "Lawns and Grasses."
- G. Restore paved areas in accordance with Division 2 Section "Hot-Mix Asphalt Paving."
- H. Upon completion of the surface restoration, perform a final clean-up within the limits of the project consisting of completely removing unused materials which will mar the appearance of the project, and sweeping dirt from pavements and structures.
- I. Maintain the restoration work for a period of 12-months after final acceptance of the Project at no additional cost to the Owner. The maintenance of the restoration shall include all labor, equipment, material, and supplies necessary, including trench refill and additional topsoil, seeding, mulching, watering, base, paving and erosion protection.

END OF SECTION 221313

## SECTION 221343 - FACILITY PACKAGED SEWAGE PUMPING STATIONS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. This Section includes a complete factory-built and tested Wetwell/Drywell Grinder Pump Station, consisting of duplex grinder pumps suitably mounted in a basin constructed of Fiberglass Reinforced Polyester Resin with dimensions and capacities as show on the Contract Drawings, NEMA 6P electrical quick disconnect (EQD), pump removal system, stainless steel discharge assembly/shut-off valve, anti-siphon valve/check valve, each assembled in the basin, electrical alarm panel and all necessary internal wiring and controls. Component type grinder pump systems that require field assembly will not be acceptable due to the potential problems that can occur during field assembly.

## 1.3 PERFORMANCE REQUIREMENTS

- A. The pumps shall be capable of delivering 15 GPM against a rated total dynamic head of 0 feet (0 PSIG), 11 GPM against a rated total dynamic head of 92 feet (40 PSIG), and 7.8 GPM against a rated total dynamic head of 185 feet (80 PSIG). The pump(s) must also be capable of operating at negative total dynamic head without overloading the motor(s). Under no conditions shall in-line piping or valving be allowed to create a false apparent head.
- B. Pressure Rating of Other Piping Components: At least equal to system operating pressure.

## 1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Show fabrication and installation details for each packaged sewage pumping station. Detail equipment assemblies and indicate dimensions; shipping, installed, and operating weights; loads; required clearances; method of field assembly; components; electrical characteristics; and location and size of each field connection.
  - 1. Wiring Diagrams: Power, signal, and control wiring.
  - 2. Pump Control Panel:

## 1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates submitted for:
  - 1. Packaged pump station.
  - 2. Control Panel
- B. Warranty: As a certification requirement, Contractor shall provide with their submittals a Warranty Performance Certification statement executed by the most senior executive officer of the grinder pump MANUFACTURER, which certifies a minimum of a 24-month warranty. They must further detail any exclusions from the warranty or additional cost items required to maintain the equipment in warrantable

condition, including all associated labor and shipping fees, and certify that the MANUFACTURER will bear all costs to correct any original equipment deficiency for the effective period of the warranty. All preventive maintenance type requirements shall be included in this form as exclusions. These requirements include, but are not limited to, unjamming of grinder mechanism, periodic motor maintenance, and periodic cleaning of liquid level controls. Should the CONTRACTOR (supplier) elect to submit a performance bond in lieu of the experience clause outlined above, this Warranty Performance Certification shall also be used as a criterion to evaluate the CONTRACTOR'S (supplier's) performance over the warranty period. A Warranty Performance Certification form is included with the bid schedule and must be completed and submitted as part of the bid package. Bids with incomplete forms or missing forms will be considered nonresponsive.

#### 1.6 CLOSEOUT SUBMITTALS

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

#### 1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with HI 1.1-1.2, "Centrifugal Pumps for Nomenclature and Definitions"; HI 1.3, "Centrifugal Pumps for Design and Application"; and HI 1.4, "Centrifugal Pumps for Installation, Operation and Maintenance," for sewage[ **and sump**] pumps.
- E. Comply with UL 778, "Motor-Operated Water Pumps," for sewage[ **and sump**] pumps.

#### 1.8 PROJECT CONDITIONS

- A. Interruption of Existing Sanitary Sewer Service: Do not interrupt sanitary sewer service to any existing user unless permitted under the following conditions and then only after arranging to provide temporary sanitary sewer service according to requirements indicated:
  - 1. Notify Engineer no fewer than seven (7) days in advance of proposed interruption of sanitary sewer service.
  - 2. Do not proceed with interruption of sanitary sewer service without Engineer and Kent County Public Works written permission.

#### 1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged sewage pumping stations that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:

- a. Structural failures including shell.
  - b. Faulty operation of sewage pumps, controls, or accessories.
  - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
- 2. Warranty Period for Shells: Two (2) years from date of Substantial Completion.
  - 3. Warranty Period for Sewage Pumps and Controls: Two (2) years from date of Substantial Completion.
  - 4. Warranty Period for Accessories: Two (2) years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 WET-WELL, PACKAGED SEWAGE PUMPING STATION

#### A. Wet-Well, Packaged Sewage Pumping Stations with Submersible Grinder Sewage Pumps:

- 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 3. Subject to compliance with requirements, provide the "W" Series Quadplex as manufactured by Environment One Corporation (E-One) or an approved equal.
- 4. Description: Wetwell/Drywell Grinder Pump Station, consisting of duplex grinder pumps suitably mounted in a basin constructed of Fiberglass Reinforced Polyester Resin with dimensions and capacities as show on the Contract Drawings, NEMA 6P electrical quick disconnect (EQD), pump removal system, stainless steel discharge assembly/shut-off valve, anti-siphon valve/check valve, each assembled in the basin, electrical alarm panel and all necessary internal wiring and controls. Component type grinder pump systems that require field assembly will not be acceptable due to the potential problems that can occur during field assembly.
  - a. Orientation: Shell underground with dry equipment chamber underground with top flush with grade.
  - b. Shell: Factory fabricated from fiberglass reinforced polyester resin.
  - c. Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches in diameter.
  - d. Cathodic Protection: Exterior magnesium anode(s).
  - e. Sewage Pumps: Four submersible grinder-type sewage pumps, quick-disconnect system, controls, and piping. Include stainless-steel grinder impeller and hermetically sealed motor with moisture-sensing probe, mechanical seals, and waterproof power cable.
- 5. Capacities and Characteristics:
  - a. Tank Capacity: 308 gallons to high level alarm
  - b. Tank Diameter: 60"
  - c. Height of Shell Base Section: 138"
  - d. Pumping Station, Inlet Pipe Size: 8"
  - e. Pumping Station, Discharge Pipe Size: Dual 1.25"
  - f. Sewage Pumps: Four required.
  - g. Each Sewage Pump:
    - 1) Capacity: 15 gpm @ 0 psig
    - 2) Speed: 1,725 rpm
    - 3) Motor Size: 1 hp.
    - 4) Electrical Characteristics:
      - a) Volts: 240 V.



- b) Phases: Single
    - c) Hertz: 60.
  - h. Pumping Station Electrical Characteristics:
    - 1) Full-Load Amperes: 20 amps (duplex condition)
    - 2) Maximum Overcurrent Protection: 30 amps
- 6. Pump:
  - a. The pump shall be a custom designed, integral, vertical rotor, motor driven, solids handling pump of the progressing cavity type with a single mechanical seal. Double radial O-ring seals are required at all casting joints to minimize corrosion and create a protective barrier. All pump castings shall be cast iron, fully epoxy coated to 8-10 mil Nominal dry thickness, wet applied. The rotor shall be through-hardened, highly polished, precipitation hardened stainless steel. The stator shall be of a specifically compounded ethylene propylene synthetic elastomer. This material shall be suitable for domestic wastewater service. Its physical properties shall include high tear and abrasion resistance, grease resistance, water and detergent resistance, temperature stability, excellent aging properties, and outstanding wear resistance. Buna-N is not acceptable as a stator material because it does not exhibit the properties as outlined above and required for wastewater service.
- 7. Grinder:
  - a. The grinder shall be placed immediately below the pumping elements and shall be direct-driven by a single, one-piece motor shaft. The grinder impeller (cutter wheel) assembly shall be securely fastened to the pump motor shaft by means of a threaded connection attaching the grinder impeller to the motor shaft. Attachment by means of pins or keys will not be acceptable. The grinder impeller shall be a one-piece, 4140 cutter wheel of the rotating type with inductively hardened cutter teeth. The cutter teeth shall be inductively hardened to Rockwell 50 – 60c for abrasion resistance. The shredder ring shall be of the stationary type and the material shall be white cast iron. The teeth shall be ground into the material to achieve effective grinding. The shredder ring shall have a staggered tooth pattern with only one edge engaged at a time, maximizing the cutting torque. These materials have been chosen for their capacity to perform in the intended environment as they are materials with wear and corrosive resistant properties.
  - b. This assembly shall be dynamically balanced and operate without objectionable noise or vibration over the entire range of recommended operating pressures. The grinder shall be constructed so as to minimize clogging and jamming under all normal operating conditions including starting. Sufficient vortex action shall be created to scour the tank free of deposits or sludge banks which would impair the operation of the pump. These requirements shall be accomplished by the following, in conjunction with the pump:
    - 1) The grinder shall be positioned in such a way that solids are fed in an upward flow direction.
    - 2) The maximum flow rate through the cutting mechanism must not exceed 4 feet per second. This is a critical design element to minimize jamming and as such must be adhered to.
    - 3) The inlet shroud shall have a diameter of no less than 5 inches. Inlet shrouds that are less than 5 inches in diameter will not be accepted due to their inability to maintain the specified 4 feet per second maximum inlet velocity which by design prevents unnecessary jamming of the cutter mechanism and minimizes blinding of the pump by large objects that block the inlet shroud.
    - 4) The impeller mechanism must rotate at a nominal speed of no greater than 1800 rpm.
  - c. The grinder shall be capable of reducing all components in normal domestic sewage, including a reasonable amount of "foreign objects," such as paper, wood, plastic, glass, wipes, rubber and the like, to finely-divided particles which will pass freely through the passages of the pump and the 1-1/4" diameter stainless steel discharge piping.

8. Electric motor:
  - a. As a maximum, the motor shall be a 1 HP, 1725 RPM, 240 Volt 60 Hertz, 1 Phase, capacitor start, ball bearing, air-cooled induction type with Class F installation, low starting current not to exceed 30 amperes and high starting torque of 8.4 foot pounds.
  - b. The motor shall be press-fit into the casting for better heat transfer and longer winding life. Inherent protection against running overloads or locked rotor conditions for the pump motor shall be provided by the use of an automatic-reset, integral thermal overload protector incorporated into the motor.
  - c. This motor protector combination shall have been specifically investigated and listed by Underwriters Laboratories, Inc., for the application. Non-capacitor start motors or permanent split capacitor motors will not be accepted because of their reduced starting torque and consequent diminished grinding capability. The wet portion of the motor armature must be 300 Series stainless. To reduce the potential of environmental concerns, the expense of handling and disposing of oil, and the associated maintenance costs, oil-filled motors will not be accepted.
9. Check valve:
  - a. The pump discharge shall be equipped with a factory installed, gravity operated, flapper-type integral check valve built into the stainless steel discharge piping. The check valve will provide a full-ported passageway when open, and shall introduce a friction loss of less than 6 inches of water at maximum rated flow.
  - b. Moving parts will be made of a 300 Series stainless steel and fabric reinforced synthetic elastomer to ensure corrosion resistance, dimensional stability, and fatigue strength. A nonmetallic hinge shall be an integral part of the flapper assembly providing a maximum degree of freedom to assure seating even at a very low back-pressure.
  - c. The valve body shall be an injection molded part made of an engineered thermoplastic resin. The valve shall be rated for continuous operating pressure of 235 psi. Ball-type check valves are unacceptable due to their limited sealing capacity in slurry applications.
10. Anti-siphon valve:
  - a. The pump discharge shall be equipped with a factory-installed, gravity-operated, flapper-type integral anti-siphon valve built into the stainless steel discharge piping. Moving parts will be made of 300 Series stainless steel and fabric-reinforced synthetic elastomer to ensure corrosion resistance, dimensional stability, and fatigue strength.
  - b. A nonmetallic hinge shall be an integral part of the flapper assembly, providing a maximum degree of freedom to ensure proper operation even at a very low pressure.
  - c. The valve body shall be injection-molded from an engineered thermoplastic resin. Holes or ports in the discharge piping are not acceptable anti-siphon devices due to their tendency to clog from the solids in the slurry being pumped.
  - d. The anti-siphon port diameter shall be no less than 60% of the inside diameter of the pump discharge piping.
11. Core unit:
  - a. The grinder pump station shall have a cartridge type, easily removable core assembly consisting of pump, motor, grinder, all motor controls, check valve, anti-siphon valve, level controls, electrical quick disconnect and wiring.
  - b. The core unit shall seal to the tank deck with a stainless steel latch assembly. The latch assembly must be actuated utilizing a single quick release mechanism requiring no more than a half turn of a wrench. The watertight integrity of each core unit shall be established by a 100 percent factory test at a minimum of 5 PSIG.

## 2.2 CONTROLS

- A. All necessary motor starting controls shall be located in the cast iron enclosure of the core unit secured by stainless steel fasteners.
- B. Control Sequence of Operation: Cycle each sewage pump on and off automatically to maintain wet-well sewage level. Automatic control operates multiple pumps if wet-well level rises above high level alarm,

until shutoff level is reached. Automatic alternator, with manual disconnect switch, changes sequence of lead-lag sewage pumps.

- C. The level sensing control housing must be integrally attached to pump assembly so that it may be removed from the station with the pump and in such a way as to minimize the potential for the accumulation of grease and debris accumulation, etc.
- D. Non-fouling wastewater level controls for controlling pump operation shall be accomplished by monitoring the pressure changes in an integral air column connected to a pressure switch. The air column shall be integrally molded from a thermoplastic elastomer suitable for use in wastewater and with excellent impact resistance. The air column shall have only a single connection between the water level being monitored and the pressure switch. Any connections are to be sealed radially with redundant O-rings. The level detection device shall have no moving parts in direct contact with the wastewater and shall be integral to the pump core assembly in a single, readily-exchanged unit.
- E. Depressing the push to run button must operate the pump even with the level sensor housing removed from the pump.
- F. Pump Control and Alarm panel:
  - 1. Each grinder pump station shall include a NEMA 4X, UL-listed alarm panel suitable for wall or pole mounting. The NEMA 4X enclosure shall be manufactured of thermoplastic polyester to ensure corrosion resistance. The enclosure shall include a hinged, lockable cover with padlock, preventing access to electrical components, and creating a secured safety front to allow access only to authorized personnel.
  - 2. The panel shall contain one 15-amp single pole circuit breaker for the alarm circuit and one 15-amp double pole circuit breaker per core for the power circuit. The panel shall contain a push-to-run feature, an internal run indicator, and a complete alarm circuit. All circuit boards in the alarm panel are to be protected with a conformal coating on both sides and the AC power circuit shall include an auto resetting fuse.
  - 3. The alarm panel shall include the following features: external audible and visual alarm; push-to-run switch; push-to-silence switch; redundant pump start; and high level alarm capability. The alarm sequence is to be as follows when the pump and alarm breakers are on:
    - a. The panel will go into alarm mode if either pump's alarm switch closes. During the initial alarm mode both pumps will run and the alarm light and buzzer will be delayed for a period of time based on user settings (default is 3-1/2 minutes). If the station is still in high-level alarm after the delay, the light and buzzer will be activated.
    - b. The audible alarm may be silenced by means of the externally mounted, push-to-silence button.
    - c. Visual alarm remains illuminated until the sewage level in the wet-well drops below the "off" setting of the alarm pressure switch.
    - d. Visual alarm shall be mounted to the top of the enclosure in such a manner as to maintain NEMA 4X rating. The audible alarm shall be externally mounted on the bottom of the enclosure, capable of 93 dB @ 2 feet. The audible alarm shall be capable of being deactivated by depressing a push-type switch that is encapsulated in a weatherproof silicone boot and mounted on the bottom of the enclosure (push-to-silence button).
- G. Service Equipment/Main Service Disconnect Breaker:
  - 1. A separate, internal breaker rated and approved for use as "service equipment" and acts as a main service disconnect of the grinder pump station shall be provided.
- H. Serviceability:
  - 1. The grinder pump core, including level sensor assembly, shall have two lifting hooks complete with lift-out harness connected to its top housing to facilitate easy core removal when necessary.
  - 2. The level sensor assembly must be easily removed from the pump assembly for service or replacement. All mechanical and electrical connections must provide easy disconnect capability for core unit removal and installation.

3. Each EQD half must include a water-tight cover to protect the internal electrical pins while the EQD is unplugged. A pump push-to-run feature will be provided for field trouble shooting. The push-to-run feature must operate the pump even if the level sensor assembly has been removed from the pump assembly.
4. All motor control components shall be mounted on a readily replaceable bracket for ease of field service.

### 2.3 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 6/A 6M, W or HP shapes, or ASTM A 36/A 36M, plates or beams.
- B. Grout: ASTM C 1107, Grade B, nonshrink cement grout.
  1. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- C. Concrete: Concrete is specified in Section 033000 "Cast-in-Place Concrete."

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of sewerage piping systems to verify actual locations of piping connections before packaged sewage pumping station installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 EARTHWORK

- A. Excavation, trenching, and backfilling are addressed in other sections of this specification.

### 3.3 INSTALLATION

- A. Install packaged sewage pumping station components where indicated, according to specific equipment and piping arrangement indicated.
- B. Shell Base Supports: Form from structural-steel beams, of number and lengths required to support bottom of shell and to anchor beams to concrete foundation.
- C. The CONTRACTOR shall be responsible for handling ground water to provide a firm, dry subgrade for the structure, and shall guard against flotation or other damage resulting from general water or flooding. Grout under and around shell. Ensure that there are no voids between foundation slab and underslab of pumping station.
- D. The grinder pump stations shall not be set into the excavation until the installation procedures and excavation have been approved by the ENGINEER.

- E. Installation shall be accomplished so that 1" to 4" of accessway, below the bottom of the lid, extends above the finished grade line. The finished grade shall slope away from the unit. The diameter of the excavated hole must be large enough to allow for the concrete anchor.
- F. Fill voids between shell sidewalls, sleeves, and piping and make watertight seal with grout.
- G. Connect anode conductors to grounding lugs on steel housing.

#### 3.4 CONNECTIONS

- A. Sanitary sewer piping installation requirements are specified in Section 221313 "Facility Sanitary Sewers." Drawings indicate general arrangement of piping.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Ground equipment according to electrical specifications.
- D. Connect wiring according to electrical specifications.

#### 3.5 BACKFILL REQUIREMENTS

- A. Proper backfill is essential to the long-term reliability of any underground structure. Several methods of backfill are available to produce favorable results with different native soil conditions. The most highly recommended method of backfilling is to surround the unit to grade using Class I or Class II backfill material as defined in ASTM 2321. Class 1A and Class 1B are recommended where frost heave is a concern, Class 1B is a better choice when the native soil is sand or if a high, fluctuating water table is expected. Class 1, angular crushed stone offers an added benefit in that it doesn't need to be compacted.
- B. Class II, naturally rounded stone, may require more compactive effort, or tamping, to achieve the proper density. If the native soil condition consists of clean compactible soil, with less than 12 percent fines, free of ice, rocks, roots and organic material, it may be an acceptable backfill. Soil must be compacted in lifts not to exceed one foot to reach a final Proctor Density of between 85 percent and 90 percent.
- C. Backfill of clean native earth, free of rocks, roots, and foreign objects shall be thoroughly compacted in lifts not exceeding 12" to a final Proctor Density of not less than 85 percent. Improper backfilling may result in damaged accessways

#### 3.6 IDENTIFICATION

- A. Install identifying labels permanently attached to equipment.
- B. Install operating instruction signs permanently attached to equipment or on pumping station wall near equipment.
- C. Arrange for installing green detectable warning tape over outside edges of underground packaged sewage pumping stations. Tape materials and their installation are specified in Section 312000 "Earth Moving."

#### 3.7 PAINTING

- A. Prepare and paint ferrous piping in wet wells, structural-steel supports, and anchor devices with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.

- B. Paint field-welded areas to match factory coating.

### 3.8 FIELD QUALITY CONTROL

- A. Kent County Public Works will perform field inspection, during construction, tests and inspections once constructed and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.. Report results in writing.
- C. Tests and Inspections:
  - 1. After installing packaged sewage pumping stations and after electrical circuitry has been energized, test for compliance with requirements. Furnish water required for pump tests.
  - 2. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 5. Complete a drawdown test to confirm pumping capacity and flowrate.
- D. Remove and replace packaged sewage pumping stations that do not pass tests and inspections and retest as specified above.

### 3.9 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Adjust pump, accessory, and control settings, and safety and alarm devices.

### 3.10 MANUALS:

- A. Contractor shall supply four copies of Operation and Maintenance Manuals to the Owner and once copy of the same to the Engineer.

END OF SECTION 221343

**SECTION 22 30 00**  
**PLUMBING EQUIPMENT**

**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Water heaters.
- B. Expansion Tanks.
- C. Pumps.
  - 1. Circulators.

**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 tapings, and performance data.
  - 2. Indicate dimensions of tanks, tank lining methods, anchors, attachments, lifting points, tapings, 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 Owner'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. Substitutions: See Section 01 60 00 - Product Requirements.
- C. Performance: See plans.
- D. Description: Water heater shall be direct fired, fully condensing, water-tube design. Power burner shall have full modulation. The minimum firing rate shall not exceed 30,000 BTU/Hr input. Water heaters that have an input greater than 30,000 BTU/Hr at minimum fire will not be considered equal. The water heater shall have the capability of discharging into a positive pressure vent. Water heater thermal efficiency shall increase with decreasing load (output), while maintaining set point. Water heater shall have an operational set point capability of 90 °F to 185 °F and shall maintain the outlet temperature within an accuracy of +/- 2 oF during load changes of up to 100% rated capacity. Heater shall operate quietly, less than 55 dba. Water heater shall be factory-fabricated, factory-assembled and factory-tested, water-tube condensing water heater with heat exchanger sealed pressure-tight, built on a steel base, including a sealed insulated sheet metal enclosure that acts as combustion-air intake plenum.
- E. Heat Exchanger: The heat exchanger shall be constructed with 316L stainless steel helical water tubes, fully floating with no welded joints in the exchanger. The exchanger will have a single-pass combustion gas flow design. The water tubes shall be 3/4" ID, with no less than 0.0469" wall thickness.
- F. Hybrid Tank: The shell assembly of the hybrid tank vessel shall have a maximum water volume of less than .6 gallon. The water heater water connections shall be 3/4 inch Flanged O Ring connections. The shell assembly shall be constructed of 316L stainless steel of 0.0488 inch wall thickness or above.
- G. Modulating Air/Fuel Valve and Burner: The water heater burner shall be capable of a 7 to 1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall be stainless fiber mesh covering a stainless steel body with spark ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input. A variable frequency drive (VFD), controlled pre-mix



blower shall be used to ensure the optimum mixing of air and fuel between the air/fuel valve and the burner.

- H. The exhaust manifold shall be of PVC, CPVC, polypropylene, stainless steel (AL29-4C) with a 3 inch diameter flue connection.
  - 1. The exhaust vent must be for use UL Listed for use with positive pressure, condensing flue gas service. Vents of PVC, CPVC, PP, SS (AL29-4C) must be used with water heaters.
  - 2. The minimum exhaust vent duct size for each water heater is three-inch diameter.
  - 3. Combustion-Air Intake: Water heaters shall be capable of drawing combustion air from the outdoors via a metal or PVC, CPVC or Polypropylene duct connected between the water heater and the outdoors.
  - 4. The minimum sealed combustion air duct size for each water heater is three-inch diameter.
  - 5. Common Vent and Common Combustion Air up to 10 heat exchangers. Consult manufacturer for common vent and combustion air sizing.
- I. Ignition: Ignition shall be via spark ignition with 100 percent main-valve shutoff and electronic flame supervision.
- J. Accessories: Provide:
  - 1. Venting Kit.
  - 2. Isolation Valves
  - 3. Condensate neutralization system
- K. Certification: As water heater by ASME, rated for output temperatures of 100 to 180 degrees F.
- L. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point field power connection to the water heater.
- M. Controls: . . .
  - 1. The water heater control system shall be a Masterless Cascading design. Lead Lag - Master / Slave control systems will not be permitted. The entire system shall be ETL recognized.
  - 2. The control panel shall consist of one individual circuit board using state-of-the-art surface-mount technology in a single enclosure. The circuit boards shall include:
    - a. A Digital touch display to indicate temperature and status
    - b. A CPU board housing all control functions
  - 3. Each board shall be individually field replaceable.
  - 4. The combustion safeguard/flame monitoring system shall use spark ignition and a rectification-type flame sensor.
  - 5. The unit shall have a selectable exhaust temperature limit suitable for venting with PVC or CPVC/Polypropylene/Stainless Steel (AL29-4C).
  - 6. The controls shall annunciate water heater and sensor status and include extensive self-diagnostic capabilities.
  - 7. The water heater control system shall incorporate the following additional features for enhanced external system interface:
    - a. Temperature set point
    - b. High Exhaust temp monitor and control. Turn down the Gas valve until the exhaust temp is kept below selected material (PVC, CPVC).
    - c. Cascading via RS232
    - d. Error Code Display / Error Code History
      - 1) Blower Fault
      - 2) Blocked Flue Fault
      - 3) Ignition Failure

- 4) Temp Sensor Short
  - 5) Temp Sensor Wiring Fault
  - 6) Flue Temp Fault
  - 7) Heat Exchanger Temp Fault
  - 8) Cascading Fault
  - 9) Water Valve Fault
  - 10) Pump Fault
  - 11) Software Fault
8. Monitor and access to daily, weekly, monthly water usages data.
  9. Monitor inlet/outlet temperatures, flow rates, flue gas temperatures, combustion rates via onboard touchscreen.
    - a. Water Heater Management: the water heater control system shall incorporate onboard multi-unit sequencing logic that would allow Masterless Cascading (Not Lead/Lag - Master/Slave) functionality & sequencing between multiple water heaters operating in parallel and must have the following capabilities:
      - 1) Efficiently sequence 2 up to 10 heat exchangers on the same system to meet the load requirement.
      - 2) Individual heat exchanger logic to enable accurate temperature control.
      - 3) Operate one motorized valve per heat exchanger as an element of the load sequencing, Valves shall close with decreased load as heaters turn off, minimum of one (depending upon Mode selection) must always stay open for recirculation.
      - 4) Automatically rotate Start/Stop amongst the heat exchangers in the chain based upon an internal calculation of run hours, water through put, burner starts and stops and length of time each burner has been firing. Sequencing is not based upon next in line (Lead/Lag), it is based upon the most logical (least used) heat exchanger in an effort to equalize unit run hours.
      - 5) Automatic bump-less transfer of sequencing in case of heat exchanger failure. All systems must be able to fail all but one heat exchanger in any order or for any reason and the last will continue to operate.
      - 6) Each heat exchanger will default to individual control upon failure of the sequencing chain.
      - 7) Masterless control, change any parameter in any one of the units and all the rest in the series will automatically adjust to the most recent parameter change.
  - N. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions and carbon monoxide in flue gas, and to achieve combustion efficiency. Perform hydrostatic testing.
  - O. Test and inspect factory-assembled water heaters, before shipping.,
  - P. Allow Owner access to source quality-control testing of water heaters. Notify Architect fourteen days in advance of testing.
  - Q.

## 2.02 DIAPHRAGM-TYPE COMPRESSION TANKS

- A. Manufacturers:
  1. Amtrol Inc: [www.amtrol.com/#sle](http://www.amtrol.com/#sle).
  2. ITT Bell & Gossett: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  3. Taco, Inc: [www.taco-hvac.com/#sle](http://www.taco-hvac.com/#sle).
- 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/#sle](http://www.armstrongpumps.com/#sle).
  - 2. ITT Bell & Gossett: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  - 3. SIHI Group: [www.sterlingsihi.com/#sle](http://www.sterlingsihi.com/#sle).
  - 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.

**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. IAPMO Z124 - Plastic Plumbing Fixtures.
- 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.
- 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 Owner'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, floor mounted, siphon jet flush action, china bolt caps.
  - 1. Flush Volume: 1.28 gallon, maximum.
  - 2. Flush Valve: Exposed (top spud).
  - 3. Flush Operation: Sensor operated, push-button override.
  - 4. Handle Height: 44 inches or less.
  - 5. Manufacturers:
    - a. American Standard Inc: [www.americanstandard.com](http://www.americanstandard.com).
    - b. Kohler.
    - c. Toto USA: [www.totousa.com](http://www.totousa.com).
    - d. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
    - 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. Sensor-Operated Type: Solenoid operator, battery powered with self-generating hydro-electric turbine, infrared sensor and over-ride push button.
  - 2. ASME A112.19.2; floor mounted, siphon jet or wall hung blow out vitreous china closet bowl, with elongated rim, 1-1/2 inch top spud, china bolt caps.
  - 3. Manufacturers:
    - a. Toto USA: [www.totousa.com](http://www.totousa.com)
    - b. Sloan Valve Company: [www.sloanvalve.com](http://www.sloanvalve.com).
    - c. Zurn Industries, Inc: [www.zurn.com](http://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/#sle](http://www.bemismfg.com/#sle).
    - c. Church Seat Company: [www.churchseats.com/#sle](http://www.churchseats.com/#sle).
    - d. Olsonite: [www.olsonite.com/#sle](http://www.olsonite.com/#sle).
    - e. Substitutions: See Section 01 60 00 - Product Requirements.
  2. Solid plastic, open front, extended back, brass bolts, with cover.
- D. Water Closet Carriers:
1. Manufacturers:
    - a. JR Smith.
    - b. Sloan Valve Company: [www.sloanvalve.com](http://www.sloanvalve.com).
    - c. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
    - 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

- A. Lavatory Manufacturers:
1. American Standard Inc
  2. Eljer
  3. Kohler Company: [www.kohler.com/#sle](http://www.kohler.com/#sle).
  4. Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).
  5. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Sensor Operated Faucet: Cast brass, chrome plated, deck mounted with sensor located on neck of spout.
1. Spout Style: Standard,
  2. Power Supply: Self-generating, hydro-powered turbine charging rechargeable battery.
  3. Mixing Valve: automatic.
  4. Water Supply: 1/2 inch compression connections.
  5. Aerator: Vandal resistant, 1 GPM, .
  6. Automatic Shut-off: 30 seconds.
  7. Sensor range: Automatically adjusts.
    - a. Accessory: Optional remote reprogrammer module to adjust pre-set factory functions.
  8. Finish: Polished chrome.
  9. Accessory: 4 inch or 8 inch deck plate.
  10. Sensor Operated Faucet Manufacturers:
    - a. American Standard Inc: [www.americanstandard.com](http://www.americanstandard.com).
    - b. Sloan Valve Company: [www.sloanvalve.com/#sle](http://www.sloanvalve.com/#sle).
    - c. Toto USA: [www.totousa.com/#sle](http://www.totousa.com/#sle).
    - d. Zurn industries, Inc: [www.zurn.com](http://www.zurn.com).
- 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.
  5. Carrier:
    - a. Manufacturers:
      - 1) JR Smith
      - 2) Sloan Valve Company: [www.sloanvalve.com](http://www.sloanvalve.com).
      - 3) Zurn Industries, Inc: [www.zurn.com/#sle](http://www.zurn.com/#sle).

- b. ASME A112.6.1M; cast iron and steel frame with tubular legs, lugs for floor and wall attachment, threaded studs for fixture hanger, or concealed arm supports bearing plate and studs.

### **2.03 WATER FOUNTAINS**

- A. Electric Water Cooler Manufacturers:
  - 1. Tri Palm International/Oasis: [www.tripalmint.com](http://www.tripalmint.com).
  - 2. Elkay Manufacturing Company: [www.elkay.com/#sle](http://www.elkay.com/#sle).
  - 3. Haws Corporation: [www.hawesco.com/#sle](http://www.hawesco.com/#sle).
- 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/#sle](http://www.elkay.com/#sle).
- 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. General construction and requirements.
- B. Applications.
- C. Single phase electric motors.
- D. 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 1/2 horsepower.

**PART 2 PRODUCTS****2.01 MANUFACTURERS**

- A. Baldor Electric Company/ABB Group: [www.baldor.com](http://www.baldor.com).
- B. Lincoln Motors: [www.lincolnmotors.com/#sle](http://www.lincolnmotors.com/#sle).
- C. A. O. Smith Electrical Products Company: [www.aosmithmotors.com/#sle](http://www.aosmithmotors.com/#sle).
- D. Reliance Electric/Rockwell Automation: [www.reliance.com](http://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. All motors shall be premium efficiency type.
  - 5. All motors which require variable speed operation shall be inverter duty or ECM 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
- 3) Minimum Percent Efficiency: 93.6% @ 1200 RPM, 94.1% @ 1800 RPM, 91.7% @ 3600 RPM
- l. 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.
  - 3) 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 - Premium Efficiency, Totally Enclosed, Fan Cooled Performance:
  - 1. 1200 rpm.
    - a. 1 hp:
      - 1) NEMA Frame: 145T.
      - 2) Minimum Percent Power Factor: 72.
      - 3) 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.
      - 3) 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.
      - 3) 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.
      - 3) 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.

- 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 3) 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.
  - 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: 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**

**SECTION 23 05 16****EXPANSION FITTINGS AND LOOPS FOR HVAC 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 23 21 13 - Hydronic Piping.
- B. Section 23 23 00 - Refrigerant 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 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/#sle](http://www.mercer-rubber.com/#sle).
  - 2. Metraflex Company: [www.metraflex.com](http://www.metraflex.com).
- B. Inner Hose: Carbon Steel.
- C. Exterior Sleeve: Single braided, stainless steel or bronze.
- D. Pressure Rating: 125 psi and 450 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.

## **2.02 FLEXIBLE PIPE CONNECTORS - COPPER PIPING**

- A. Manufacturer:
  - 1. Mercer Rubber Company: [www.mercer-rubber.com/#sle](http://www.mercer-rubber.com/#sle).
  - 2. Metraflex Company: [www.metraflex.com/#sle](http://www.metraflex.com/#sle).
- B. Inner Hose: Bronze.
- C. Exterior Sleeve: Braided bronze.
- D. Pressure Rating: 125 psi and 450 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 - TWO-PLY BRONZE BELLOWS TYPE**

- A. Manufacturers:
  - 1. Mercer Rubber Company: [www.mercer-rubber.com/#sle](http://www.mercer-rubber.com/#sle).
  - 2. Metraflex Company: [www.metraflex.com/#sle](http://www.metraflex.com/#sle).
- B. Construction: Bronze with anti-torque device, limit stops, internal guides.
- C. Pressure Rating: 125 psi and 400 degrees F.
- D. Maximum Compression: 1-3/4 inches.
- E. Maximum Extension: 1/4 inch.
- F. Joint: As specified for pipe joints.
- G. Size: Use pipe sized units.
- H. Application: Copper piping.

## **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 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.

**END OF SECTION**

**SECTION 23 05 19**  
**METERS AND GAGES FOR HVAC PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

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

**1.02 RELATED REQUIREMENTS**

- A. Section 23 21 13 - Hydronic Piping.
- B. Section 23 09 23 - Direct-Digital Control System for HVAC.
- C. Section 23 09 93 - Sequence of Operations for HVAC Controls.

**1.03 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.
- K. UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service.

**1.04 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: Manufacturer's Standards and Operations and maintenance manuals and catalog cuts.

**1.05 FIELD CONDITIONS**

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

**1.06 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 POSITIVE DISPLACEMENT METERS (LIQUID)**

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  - 2. Venture Measurement Company: [www.venturemeasurement.com/#sle](http://www.venturemeasurement.com/#sle).
  - 3. McCrometer: [www.mccrometer.com](http://www.mccrometer.com).
  - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. AWWA C700, positive displacement disc type suitable for fluid with bronze case and cast iron frost-proof, breakaway bottom cap, hermetically sealed register, remote reading to AWWA C706.
- C. Meter: Brass body turbine meter with magnetic drive register.
  - 1. Service: Cold water, 122 degrees F.
  - 2. Service: Hot water, 200 degrees F.
  - 3. Accuracy: 1-1/2 percent.
  - 4. Maximum Counter Reading: 10 million gallons.
  - 5. Size: 1/2 inch.

**2.02 PRESSURE GAGES**

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  - 2. Moeller Instrument Co., Inc: [www.moellerinstrument.com/#sle](http://www.moellerinstrument.com/#sle).
  - 3. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).
- 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: 2-1/2 inch diameter.
  - 3. Mid-Scale Accuracy: One percent.
  - 4. 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 or Brass, 1/4 inch angle or straight pattern.

**2.04 STEM TYPE THERMOMETERS**

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  - 2. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).
  - 3. Weksler Glass Thermometer Corp: [www.wekslerglass.com/#sle](http://www.wekslerglass.com/#sle).
- 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: 7 inch scale.
  - 2. Window: Clear glass or Lexan.
  - 3. Stem: Brass.
  - 4. Accuracy: 2 percent, per ASTM E77.
  - 5. 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: 7 inch scale.
  2. Window: Clear glass or Lexan.
  3. Stem: 3/4 inch NPT brass.
  4. Accuracy: 2 percent, per ASTM E77.
  5. Calibration: Degrees F.

## **2.05 DIAL THERMOMETERS**

- A. Manufacturers:
1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  2. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).
  3. Weksler Glass Thermometer Corp: [www.wekslerglass.com/#sle](http://www.wekslerglass.com/#sle).
- B. Thermometers - Fixed Mounting: Dial type bimetallic actuated; ASTM E1; stainless steel case, silicone fluid damping, white with black markings and black pointer, hermetically sealed lens, stainless steel stem.
1. Size: 2-1/2 inch diameter dial.
  2. Lens: Clear glass or Lexan.
  3. Accuracy: 1 percent.
  4. Calibration: Degrees F.
- C. Thermometer: ASTM E1, stainless steel case, adjustable angle with front recalibration, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
1. Size: 3 inch diameter dial.
  2. Lens: Clear glass or Lexan.
  3. Accuracy: 1 percent.
  4. Calibration: Degrees F.
- D. Thermometers: Dial type vapor or liquid actuated; ASTM E1; stainless steel case, with brass or copper bulb, copper or bronze braided capillary, white with black markings and black pointer, glass lens.
1. Size: 2-1/2 inch diameter dial.
  2. Lens: Clear glass or Lexan.
  3. Length of Capillary: Minimum 5 feet.
  4. Accuracy: 2 percent.
  5. Calibration: Degrees F.

## **2.06 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.

## **2.07 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.

**2.08 STATIC PRESSURE GAGES**

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  - 2. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).
  - 3. Weksler Glass Thermometer Corp: [www.wekslerglass.com/#sle](http://www.wekslerglass.com/#sle).
- B. 2-1/2 inch diameter dial in metal case, diaphragm actuated, black figures on white background, front recalibration adjustment, 2 percent of full scale accuracy.
- C. Inclined manometer, red liquid on white background with black figures, front recalibration adjustment, 3 percent of full scale accuracy.
- D. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4 inch diameter tubing.

**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 to isolate each gage. Provide siphon on gages in steam systems. 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 thermometers in air duct systems on flanges.
- G. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets. Refer to Section 23 09 43. Where thermometers are provided on local panels, duct or pipe mounted thermometers are provided on local panels, duct or pipe mounted thermometers are not required.
- H. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.
- I. Coil and conceal excess capillary on remote element instruments.
- J. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- K. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- L. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- M. 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 SCHEDULE**

- A. Pressure Gages, Location:
  - 1. Pumps.
  - 2. Expansion tanks.
  - 3. Pressure tanks.
  - 4. Standpipe, highest points.

5. Standpipe and sprinkler water supply connection.
  6. Sprinkler system.
  7. Pressure reducing valves.
  8. Backflow preventers.
- B. 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.
  4. Chiller - inlets and outlets.
  5. Boiler - inlets and outlets.
- C. Stem Type Thermometers, Location and Scale Range:
1. Headers to central equipment.
  2. Coil banks - inlets and outlets.
  3. Heat exchangers - inlets and outlets.
  4. Boilers - inlets and outlets.
  5. Chiller - inlets and outlets.
  6. Water zone supply and return.
  7. After major coils.
  8. Domestic hot water supply and recirculation.
- D. Thermometer Sockets, Location:
1. Control valves 1 inch & larger - inlets and outlets.
  2. Reheat coils - inlets and outlets.
  3. Cabinet heaters - inlets and outlets.
  4. Unit heaters - inlets and outlets.
- E. Dial Thermometers, Location and Scale Range:
1. ERV Outside air.
  2. ERV Return air.
  3. ERV Exhaust air.
  4. ERV Supply air.
- F. Static Pressure and Filter Gages, Location and Scale Range:
1. Built up filter banks.
  2. Unitary filter sections.
  3. Supply fan discharge.
  4. Building static.

**END OF SECTION**

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

**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Vibration isolators.
- B. Seismic restraints for suspended components and equipment.
- C. Roof curbs.
- D. 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](http://www.isolationtech.com).
- B. Kinetics Noise Control, Inc: [www.kineticsnoise.com/#sle](http://www.kineticsnoise.com/#sle).
- C. Mason Industries: [www.mason-ind.com/#sle](http://www.mason-ind.com/#sle).

**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.

**2.03 VIBRATION ISOLATORS**

- A. Non-Seismic Type:
  - 1. All Elastomeric-Fiber Glass Pads:
    - a. Configuration: Flat or molded.
    - b. Thickness: 0.25 inch minimum.
    - c. Assembly: Single or multiple layers using bonded, galvanized sheet metal separation plate between each layer with load plate providing evenly distributed load over pad surface.
  - 2. Elastomeric Mounts:
    - a. Material: Oil, ozone, and oxidant resistant compounds.
    - b. Assembly: Encapsulated load transfer plate bolted to equipment and base plate with anchor hole bolted to supporting structure.
  - 3. Steel Springs:
    - a. Assembly: Freestanding, laterally stable without housing.
    - b. Leveling Device: Rigidly connected to equipment or frame.
  - 4. Restrained Steel Springs:
    - a. Housing: Rigid blocking during rigging prevents equipment installed and operating height from changing during temporary weight reduction.



- b. Equipment Wind Loading: Adequate means for fastening isolator top to equipment and isolator base plate to supporting structure.
- 5. Elastomeric Hangers:
  - a. Housing: Steel construction containing elastomeric isolation element to prevent rod contact with housing and short-circuiting of isolating function.
  - b. Incorporate steel load distribution plate sandwiching elastomeric element to housing.
- 6. Spring Hanger:
  - a. Housing: Steel construction containing stable steel spring and integral elastomeric element preventing metal to metal contact.
  - b. Bottom Opening: Sized to allow plus/minus 15 degrees rod misalignment.
- 7. Combination Elastomeric-Spring Hanger:
  - a. Housing: Steel construction containing stable steel spring with elastomeric element in series isolating upper connection of hanger box to building structure.
  - b. Bottom Opening: Sized to allow plus/minus 15 degrees rod misalignment.
- 8. Thrust Restraints:
  - a. Housing: Steel construction containing stable steel spring and integral elastomeric element installed in pairs to resist air pressure thrusts.
  - b. Bottom Openings: Sized to allow plus/minus 15 degrees rod misalignment.
- B. Seismic Type:
  - 1. Coil Springs Consisting of Single Elements:
    - a. Housing: Manufactured from cast iron material.
    - b. Ductile Material: Designed and rated for seismic applications.
    - c. Spring: Restrained by housing without significant degradation of vibration isolation capabilities during normal equipment operating conditions.
    - d. Resilient Snubbing Grommet System: Incorporated and designed with clearances of no more than 0.25 inch in any direction preventing direct metal-to-metal contact between supported member and fixed restraint housing.
    - e. Resilient Pad: Located in series with spring.
    - f. Coil Springs: Color coded elements to have a lateral stiffness greater than 0.8 times the rated vertical stiffness with 50 percent overload capacity.
    - g. Finish: Suitable for the application.
  - 2. All Directional Elastomeric:
    - a. Material: Molded from oil, ozone, and oxidant resistant compounds.
    - b. Operating Parameters: Designed to operate within the isolator strain limits providing maximum performance and service life.
    - c. Attachment Method: Encapsulated load transfer plate bolted to equipment and base plate with anchor hole bolted to supporting structure.
    - d. Rating: Cast iron and aluminum housings rated for seismic restraint applications.
    - e. Minimum Operating Static Deflections: Deflections indicated in project documents are not to exceed published load capacities.

#### **2.04 SEISMIC RESTRAINTS FOR SUSPENDED COMPONENTS AND EQUIPMENT**

- A. Comply with:
  - 1. ASHRAE (HVACA) Handbook - HVAC Applications.
  - 2. FEMA 412.
  - 3. FEMA 413.
  - 4. FEMA 414.
  - 5. FEMA E-74.
  - 6. SMACNA (SRM).
- B. Cable Restraints:
  - 1. Wire Rope: Steel wire strand cables sized to resist seismic loads in all lateral directions.

2. Protective Thimbles: Eliminates potential for dynamic cable wear and strand breakage.
  3. Size: Based on the lesser of cable capacity or anchor load taking into account bracket geometry.
  4. Connections:
    - a. Use overlapping wire rope U clips, cable clamping bolts, swaged sleeves or seismically rated tool-less wedge insert lock connectors.
    - b. Internally brace clevis hanger bracket cross bolt to prevent deformation.
  5. Vertical Suspension Rods: Attach required bracing of sufficient strength to prevent rod buckling from vertical compression forces utilizing series of attachment clips.
- C. Rigid Restraints:
1. Structural Element: Sized to resist seismic loads in all lateral directions and carry both compressive and tensile loading.
  2. Size: Based on the lesser of cable capacity or anchor load taking into account bracket geometry.
  3. Connections: Internally brace clevis hanger bracket cross bolt to prevent deformation.
  4. Static Support System: Anchorage capable of carrying additional tension loads generated by the vertical component of the rigid brace compression which is additive to any static load requirements on the system.
  5. Vertical Suspension Rods: Attached required bracing of sufficient strength to prevent rod buckling from vertical compression forces utilizing series of attachment clips.

## **2.05 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.
- B. Seismic Type Non-Isolated Curb and Fabricated Equipment Piers:
1. Location: Between structure and rooftop equipment.
  2. Construction: Steel.
  3. Weather exposed components consist of corrosion resistant materials.

## **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.

**END OF SECTION**

**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.

**2.02 MANUFACTURERS**

- A. Brady Corporation: [www.bradycorp.com](http://www.bradycorp.com).
- B. Champion America, Inc: [www.Champion-America.com](http://www.Champion-America.com).
- C. Seton Identification Products: [www.seton.com/aec](http://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. For refrigerant piping, provide pipe markers to identify the following:
  - 1. Refrigerant state (high pressure gas, low pressure gas, or liquid)
  - 2. Connected equipment, HP or FC.
  - 3. Connected room number(s), where applicable.
- C. 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.
- D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- E. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.
- 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. Coordinate 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. Install tags with corrosion resistant chain.
- C. Refrigerant piping shall be labeled with the refrigerant state (high pressure gas, low pressure gas, or liquid) as well as the connected fan coil and associated room served.
- 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**

**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. Testing, adjustment, and balancing of refrigerating systems.
- C. Measurement of final operating condition of HVAC systems.
- D. Sound measurement of equipment operating conditions.
- E. Vibration measurement of equipment operating conditions.
- F. Commissioning activities.

**1.02 RELATED REQUIREMENTS**

- A. Section 01 91 10 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- 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. 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 and 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 Architect.
  - 2. Submit to the Commissioning Authority, Construction Manager, and HVAC controls contractor.
  - 3. Submit six weeks prior to starting the testing, adjusting, and balancing work.
  - 4. Include certification that the plan developer has reviewed the contract documents, the equipment and systems, and the control system with the Architect 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.
    - b. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
    - c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
    - d. Identification and types of measurement instruments to be used and their most recent calibration date.

- e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
  - f. Final test report forms to be used.
  - g. Detailed step-by-step procedures for TAB work for each system and issue, including:
    - 1) Terminal flow calibration (for each terminal type).
    - 2) Diffuser proportioning.
    - 3) Branch/submain proportioning.
    - 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.
  - l. 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 Architect 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 Architect.
  - 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](http://www.aabchq.com); upon completion submit AABC National Performance Guaranty.
  - b. NEBB, National Environmental Balancing Bureau: [www.nebb.org/#sle](http://www.nebb.org/#sle).
  - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: [www.tabbcertified.org/#sle](http://www.tabbcertified.org/#sle).
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.
- F. TAB Supervisor Qualifications: Professional Engineer licensed in the State in which the Project is located.

### **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. 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 Architect 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 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 Owner.
- 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.

**3.07 COMMISSIONING**

- A. Perform prerequisites prior to starting commissioning activities.
- B. Fill out Prefunctional Checklists for:
  - 1. Air side systems.
  - 2. Refrigeration systems
  - 3. Packaged rooftop units.
  - 4. Kitchen ventilation systems.
  - 5. VRF systems.
  - 6. Energy recovery ventilators.
  - 7. Exhaust fans.
- 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.

**3.08 SCOPE**

- A. Test, adjust, and balance the following:
  - 1. Plumbing Pumps
  - 2. Air Cooled Refrigerant Condensers

3. Fan Coils, Including VRF Fan Coils
4. Packaged Roof Top Heating/Cooling Units.
5. Terminal Heat Transfer Units
6. Air Handling Units/Rooftop Mounted Air handling units
7. Fans
8. Air Filters
9. 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. Gas flow rate
  7. Entering air temperature, design and actual
  8. Leaving air temperature, design and actual
  9. 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

- I. 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. Flow Measuring Stations:
  1. Identification/number
  2. Location
  3. Size
  4. Manufacturer
  5. Model number
  6. Serial number
  7. Design Flow rate
  8. Design pressure drop
  9. Actual/final pressure drop
  10. Actual/final flow rate
  11. Station calibrated setting
- N. Terminal Unit Data:
  1. Manufacturer
  2. Type, constant, variable, single, dual duct
  3. Identification/number
  4. Location
  5. Model number
  6. Size
  7. Minimum static pressure
  8. Minimum design air flow
  9. Maximum design air flow
  10. Maximum actual air flow
  11. Inlet static pressure
- O. 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
- P. Sound Level Reports:
  1. Location
  2. Octave bands - equipment off
  3. Octave bands - equipment on
- Q. Vibration Tests:
  1. Location of points:
    - a. Fan bearing, drive end
    - b. Fan bearing, opposite end
    - c. Motor bearing, center (if applicable)
    - d. Motor bearing, drive end
    - e. Motor bearing, opposite end



- f. Casing (bottom or top)
  - g. Casing (side)
  - h. Duct after flexible connection (discharge)
  - i. Duct after flexible connection (suction)
- 2. Test readings:
  - a. Horizontal, velocity and displacement
  - b. Vertical, velocity and displacement
  - c. Axial, velocity and displacement
- 3. Normally acceptable readings, velocity and acceleration
- 4. Unusual conditions at time of test
- 5. Vibration source (if non-complying)

**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 experience and 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](http://www.knaufusa.com).
  - 2. Johns Manville Corporation: [www.jm.com/#sle](http://www.jm.com/#sle).
  - 3. Owens Corning Corp: [www.owenscorning.com/#sle](http://www.owenscorning.com/#sle).
  - 4. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
- 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](http://www.knaufusa.com).
  - 2. Johns Manville Corporation: [www.jm.com/#sle](http://www.jm.com/#sle).
  - 3. Owens Corning Corp: [www.owenscorning.com](http://www.owenscorning.com).
  - 4. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
- 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](http://www.soundseal.com)
  - 2. Kinetics Noise Control: [www.kineticsnoise.com](http://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. Ducts Exposed in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting unless noted otherwise.
- F. Exterior Applications: Provide insulation with vapor barrier jacket. Cover with with calked aluminum jacket with seams located on bottom side of horizontal duct section. Provide tapered caps on all horizontal ducts for shedding water.
- G. 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
  - b. Thickness: 2 inches.
  - c. Minimum "R" value: 6.
  - d. Jacket: Foil and paper.
  - e. Vapor Retarder Required: Yes.
- 8. 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-walled spiral ductwork in areas not concealed above ceilings and where noted.
- 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-walled spiral ductwork in areas not concealed above ceilings and where noted.
- 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-walled spiral ductwork in areas not concealed above ceilings and where noted.
- 11. Service: Rectangular, supply-air ducts, exposed.
  - a. Material: Mineral-fiber board.
  - b. Thickness: 2 inches.
  - c. Minimum "R" value: 6.
  - d. Jacket: Canvas, painted to architects specifications.
  - 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: Canvas, painted to architects specifications.
  - 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: Canvas, painted to architects specifications.
  - e. Vapor Retarder Required: Yes.
- 14. Service: Rectangular, range-hood exhaust ducts, concealed.

- a. Material: Calcium silicate.
  - b. Thickness: 2 inches.
  - c. Field-Applied Jacket: Glass cloth.
  - d. Vapor Retarder Required: No.
15. Service: Rectangular, range-hood exhaust ducts, exposed.
- a. Material: Calcium silicate.
  - b. Thickness: 2 inches.
  - c. Field Applied Jacket: Stainless steel.
  - d. Vapor Retarder Required: No.

**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: aluminum
    - 1) 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: aluminum
    - 1) 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: aluminum
    - 1) 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 FLEXIBLE ELASTOMERIC CELLULAR INSULATION**

- A. Manufacturer:
  - 1. Armacell International: [www.armacell.com/#sle](http://www.armacell.com/#sle).
  - 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.

#### **2.03 JACKETS**

- A. PVC Plastic:
  - 1. Manufacturers:
    - a. Johns Manville Corporation: [www.jm.com/#sle](http://www.jm.com/#sle).
    - 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 Not Concealed Above Ceilings: Finish with PVC jacket.
- 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.
  - 2. Service: All refrigerant piping.
    - a. Operating Temperature: 35 to 140 deg F.

- b. Insulation Material: Flexible elastomeric.
- c. Insulation Thickness: Apply the following insulation thicknesses:
  - 1) Pipe, 1" or less: 1.0 inch.
  - 2) Pipe, 1-1/4" and up: 1.5 inch.
- d. Jacket: PVC where not concealed above ceilings.
- e. Vapor Retarder Required: Yes.
- f. Finish: None.

C. EXTERIOR PIPING INSULATION APPLICATION SCHEDULE

- 1. Service: All refrigerant piping.
  - a. Operating Temperature: 35 to 140 deg F.
  - b. Insulation Material: Flexible elastomeric.
  - c. Insulation Thickness: Apply the following insulation thicknesses:
    - 1) Pipe, 1" or less: 1.0 inch.
    - 2) Pipe, 1-1/4" to 2": 1.5 inch.
    - 3) Pipe, 2-1/2" and up: 1.5 inch.
  - d. Jacket: Aluminum.
  - e. Vapor Retarder Required: Yes.
  - f. Finish: None.

**END OF SECTION**

**SECTION 23 08 00**  
**COMMISSIONING OF HVAC**

**PART 1 GENERAL**

**1.01 SUMMARY**

- A. See Section 01 91 13 - General Commissioning Requirements for overall objectives; comply with the requirements of Section 01 91 13.
- B. 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.
- C. The Commissioning Authority (CA) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Contractor's use.
- D. The entire HVAC system is to be commissioned, including commissioning activities for the following specific items:
  - 1. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.
- E. 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 SUBMITTALS**

- A. 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.
- B. 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.
- C. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.
- D. 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. Air handler 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).
- E. 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.
- F. 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.
- G. Training Manuals: See Section 01 79 00 for additional requirements.

1. Provide three extra copies 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 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 Owner; such equipment, tools, and instruments are to become the property of 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.
- 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.

### **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).
- E. Isolation Valve or System Valve Leak Check: For valves not by coils.
  1. With full pressure in the system, command valve closed.
  2. Use an ultra-sonic flow meter to detect flow or leakage.
- F. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to 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 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 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 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. All control strategies and sequences not tested during controlled equipment testing.
- H. 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 Owner.

### **3.05 OPERATION AND MAINTENANCE MANUALS**

- A. See Section 01 78 00 for additional requirements.
- B. Add design intent documentation furnished by Architect to manuals prior to submission to 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 Owner.

### **3.06 DEMONSTRATION AND TRAINING**

- A. See Section 01 79 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 Owner'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:
- 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 8 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 may be held on-site or at the manufacturer's facility.
    - b. If held off-site, the training may occur prior to final completion of the system installation.
    - c. For off-site training, Contractor shall pay expenses of up to two attendees.
  2. Phase 2 - Integrating with HVAC Systems: Provide minimum of 8 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. Point database entry and modifications.
  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 Owner. 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 23****DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC**

- .01 NOTE:CONTRACOR IS REQUIRED TO PROVIDE ALL COMPONENTS, WIRING, LABOR, APPURTENANCES, AND COORDINATION SERVICES TO DELIVER A FULLY-FUCNTIONAL BUILDING AUTOMATION SYSTEM.**

**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. 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.
- 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. Controls for variable refrigerant flow (VRF) system, packaged rooftop units, 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.
- F. 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.

- G. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

#### **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.
  - 3. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
  - 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 Owner'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 the State in which the Project is located.
- 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 five 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 two 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 8 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 6000 - Product Requirements, for additional provisions.

**1.11 PROTECTION OF SOFTWARE RIGHTS**

- A. Prior to delivery of software, the Owner 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 (Using Tridium-Based FX) by Modern Controls
- B. Tridium-Based BuildingLogix / Lynxspring / KMC Controls by Seiberlich Trane
- C. Substitutions: Not Permitted.

**2.02 CONTROLLERS**

- A. BUILDING LEVEL 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. CUSTOM APPLICATION CONTROLLERS
  - 1. General:
    - a. Provide sufficient memory to support controller's operating system, database, and programming requirements.
    - b. Share data between networked, microprocessor based controllers.
    - c. 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.
    - d. Utilize real-time clock for scheduling.
    - e. Continuously check processor status and memory circuits for abnormal operation.
    - f. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
    - g. Communication with other network devices to be based on assigned protocol.
  - 2. Communication:
    - a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
    - b. 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 LED's 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.
- C. APPLICATION SPECIFIC CONTROLLERS
1. General:
    - a. Not fully user programmable, microprocessor based controllers dedicated to control specific equipment.
    - b. Customized for operation within the confines of equipment served.
    - c. Communication with other network devices to be based on assigned protocol.
  2. Communication:
    - a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
    - b. 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.
- D. 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. Limit the use of three point, floating devices to the following zone and terminal unit control applications:
    - 1) VAV or duct terminal units.
    - 2) Duct mounted heating coils.
    - 3) Zone dampers.
    - 4) Radiation.
  - c. 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.

### **2.03 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.
  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.

**2.04 OPERATOR STATION****A. Work Station:**

1. Provide desktop personal computer as BAS interface with specifications as required to operate BAS software and to meet minimum performance requirements below. Provide with monitor, mouse, mousepad and keyboard.
2. Configuration: IBM-compatible Intel Core i5-700T based microcomputer system or better with 8 GB dual-channel RAM, a minimum 500 GB hard-drive, DVD+/-RW Drive, internal network LAN card, four USB ports, and Windows 10 or higher operating system.
3. Provide properly sized uninterruptible power supply system (UPS) for the work station that also provides power conditioning.
4. Provide fully licensed anti-virus software package with the system.
5. Display: 17" Flat-panel LCD display with stand.
6. Keyboard: Low profile, detachable, having Qwerty layout plus a 10 key numeric keypad, dedicated function keys.
7. Mouse: Software supported mouse with support software including self building menus and displays of system operations and functions.
8. Display: Super video color graphics adapter (SVGA), 17 inch non-interlaced color monitor, super high definition, 2560 x 1600.
9. 600 dpi laser printer of at least 4 pages per minute speed. Include 8 1/2 X 11 and 8.5 X 11 paper trays.

**2.05 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.

**2.06 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.

**2.07 SYSTEM SOFTWARE**

- A. Operating System:
  - 1. Concurrent, multi-tasking capability.
    - a. Common Software Applications Supported: Microsoft Excel.
  - 2. System Graphics:
    - a. Allow up to 10 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:
    - a. HVAC Equipment:
      - 1) Air Handlers.
      - 2) Terminal HVAC Units.
      - 3) Fan Coil Units.
      - 4) VRF Fan Coils.
      - 5) VRF Heat Pumps.
      - 6) Energy Recovery Ventilators with Electric Duct Heating Coils.
      - 7) Packaged Rooftop Units.
    - b. Ancillary Equipment:
      - 1) Fans.
      - 2) Pumps.
      - 3) Coils.
      - 4) Valves.
      - 5) Piping.

- 6) Dampers.
    - 7) Ductwork.
  - c. File Format Compatible with Graphics Generation Package Program.
- 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.
- 6) 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 can 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.

## **2.08 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.
  2. Exception Schedules:
    - a. Based on any day of the year.
    - b. Defined up to one year in advance.
    - c. Automatically discarded and replaced with standard schedule for that day of the week upon execution.
  3. Holiday or Special Schedules:
    - a. Capability to define up to 99 schedules.
    - b. Repeated annually.
    - c. Length of each period is operator defined.
- 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:

- 1) Start programs.
  - 2) Print.
  - 3) Logged.
  - 4) Custom messaging.
  - 5) Graphical displays.
  - 6) Dial out to workstation receivers via system protocol.
- 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.
    - c. Equipment off/on prioritization.
  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.

## **2.09 OPERATING SYSTEM SOFTWARE**

- A. 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.
- B. Operator System Access: Via software password with minimum 30 access levels at work station and minimum 3 access levels at each control unit.
- C. 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.
- D. 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.
- E. 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.
- F. 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.
- G. 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.
- H. Automatic Restart: Automatically restart field equipment on restoration of power. Provide time delay between individual equipment restart and time of day start/stop.
- I. 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.
- J. 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.
- K. Parameter Save/Restore: Store most current operating system, parameter changes, and modifications on disk or diskette.
- L. 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.
- M. 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.
- N. 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.
- O. 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.

## **2.10 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.

## **2.11 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.
- C. Supply Air Reset:
- 1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.
  - 2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
    - a. Raising cooling temperatures to highest possible value.
    - b. Reducing heating temperatures to lowest possible level.
  - 3. Operator commands:
    - a. Add/delete fan status point.
    - b. Lock/unlock program.
    - c. Request HVAC point summary.
    - d. Add/Delete discharge controller point.
    - e. Define discharge controller parameters.
    - f. Add/delete air flow rate.
    - g. Define space load and load parameters.
    - h. Request space load summary.
  - 4. Control summary:
    - a. HVAC control system status (begin/end).
    - b. Supply air reset system status.
    - c. Optimal run time system status.
    - d. Heating and cooling loop.
    - e. High/low limits.
    - f. Deadband.
    - g. Response timer.
    - h. Reset times.
  - 5. Space load summary:
    - a. HVAC system status.
    - b. Optimal run time status.
    - c. Heating/cooling loop status.
    - d. Space load point ID.
    - e. Current space load point value.
    - f. Control heat/cool limited.
    - g. Gain factor.
    - h. Calculated reset values.
    - i. Fan status point ID and status.
    - j. Control discharge temperature point ID and status.
    - k. Space load point ID and status.
    - l. Air flow rate point ID and status.
- D. Enthalpy Switchover:
- 1. Calculate outside and return air enthalpy using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.
  - 2. Operator commands:
    - a. Add/delete fan status point.
    - b. Add/delete outside air temperature point.
    - c. Add/delete discharge controller point.
    - d. Define discharge controller parameters.
    - e. Add/delete return air temperature point.
    - f. Add/delete outside air dew point/humidity point.

- g. Add/delete return air dew point/humidity point.
- h. Add/delete damper switch.
- i. Add/delete minimum outside air.
- j. Add/delete atmospheric pressure.
- k. Add/delete heating override switch.
- l. Add/delete evaporative cooling switch.
- m. Add/delete air flow rate.
- n. Define enthalpy deadband.
- o. Lock/unlock program.
- p. Request control summary.
- q. Request HVAC point summary.
- 3. Control summary:
  - a. HVAC control system begin/end status.
  - b. Enthalpy switchover optimal system status.
  - c. Optimal return time system status.
  - d. Current outside air enthalpy.
  - e. Calculated mixed air enthalpy.
  - f. Calculated cooling coil enthalpy using outside air.
  - g. Calculated cooling coil enthalpy using mixed air.
  - h. Calculated enthalpy difference.
  - i. Enthalpy switchover deadband.
  - j. Status of damper mode switch.

## 2.12 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.
  - l. 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 all Owner-provided equipment along with all contractor-provided equipment as required to provide a complete, fully functional building automation system.
- B. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
- C. 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.
- D. Provide with 120v AC, 15 amp dedicated emergency power circuit to each programmable control unit.
- E. Provide conduit and electrical wiring in accordance with Section 26 27 17. Electrical material and installation shall be in accordance with appropriate requirements of .
- F. Ensure that all components necessary to execute the sequences of operation are coordinated and installed by all contractors.

#### **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 Owner'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 Owner.

#### **3.05 MAINTENANCE**

- A. Provide service and maintenance of energy management and control systems for two years from Date of Substantial Completion.
- B. Provide four complete inspections, one in each season, to inspect, calibrate, and adjust controls as required, and submit written reports.

**END OF SECTION**

**SECTION 23 09 93****SEQUENCE OF OPERATIONS FOR HVAC CONTROLS**

**THE MECHANICAL CONTRACTOR SHALL PROVIDE ALL NECESSARY LABOR MATERIALS TO PROVIDE A FULLY FUNCTIONAL BUILDING AUTOMATION SYSTEM FOR THE PROJECT. THIS INCLUDES ALL CONTROL COMPONENTS, CONTROLLERS, WIRING, PROGRAMMING, AND COORDINATION BETWEEN TRADES TO ACCOMPLISH THE SEQUENCE OF OPERATIONS HEREIN. CONTRACTOR SHALL ENSURE THAT ALL COMPONENTS ARE COORDINATED BETWEEN EQUIPMENT SUPPLIERS AND CONTROLS VENDOR FOR ALL EQUIPMENT.**

**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. Wall-Mounted Ductless Split Heat Pumps
  - 2. Energy Recovery Ventilators with Duct-Mounted Heating Coils
  - 3. Exhaust Fans
  - 4. Kitchen Exhaust Hoods / Kitchen Make-Up Air Systems
  - 5. Variable Refrigerant Volume (VRF/VRV) Systems
  - 6. Cabinet heaters / Unit Heaters
  - 7. Electric Convectors and Radiators
  - 8. Packaged Rooftop Units
  - 9. Energy and Water Metering and Monitoring
  - 10. Site Lighting Control
  - 11. Customized Load Shedding Control

**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.

**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.
  - l. 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 the State in which the Project is located.

**PART 2 PRODUCTS - NOT USED****PART 3 EXECUTION****3.01 GENERAL SYSTEM DESIGN AND OPERATION STANDARDS**

- A. The BAS shall control the mechanical systems within the site based upon the following design parameters:
  - 1. The large-group areas (gymnasium, cafeteria) shall be heated and cooled via packaged rooftop air-handling units utilizing gas-fired condensing burners for heating, direct-expansion cooling with hot-gas bypass and hot-gas reheat, and energy recovery sections. These units will control supply airflow, space temperature, discharge air temperature and local humidity.
  - 2. The general occupied areas (including but not limited to offices, classrooms, corridors, conference rooms, group toilet rooms, etc.) shall be heated and cooled by a VRF heat-pump unit, with outdoor-air delivered via a dedicated energy-recovery ventilation unit. All 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 adjustment (flat plate-type sensors). 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. The local VRF unit controllers are to be mounted above the ceiling, at the unit.
  - 3. Ancillary spaces will be heated by a combination of unit heaters or radiant heating as indicated on the drawings.
- B. Each unit shall be controlled by an individual DDC Controller and all required sensors, control valves, and appurtenances required to complete the sequence of operation. Units shall include occupied/unoccupied control, night-setback, morning warm-up/cool-down, and enthalpy-based economizer functions.
- C. The VRF heat-pump units shall also be controlled by the BAS. The units shall be controlled by a new DDC controller and DDC-based temperature sensors with no adjustment or display. 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.

**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. Provide a motor operated damper on the fan. Damper to open when fan is engaged.
  - 4. Exhaust 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 engaged.
  - 3. Electrical 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. Exhaust Fans Serving Attic Spaces
  - 1. Exhaust fans serving attic spaces shall be controlled by a line voltage humidistat set to engage the fan when the humidity exceeds 60% RH in the space (adjustable).
  - 2. Provide a motor operated damper on the fan and associated supply-air louver. Dampers to open when fan is engaged.
  - 3. Attic Exhaust Fan Monitoring:
    - a. Provide a current sensor indicated 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 relative humidity reading in each space on the monitoring screen at the BAS terminal.
- D. Exhaust Fans Serving Dishwashers
  - 1. The exhaust fans serving each dishwasher shall be interlocked with associated dishwasher such that the fan is energized when the corresponding dishwasher is in operation and shall be de-energized when the dishwasher is not in use.
  - 2. Provide a current sensor for each fan to show operational status.
  - 3. Provide a motor operated damper on the fan. Damper is to open when fan is engaged.
  - 4. The following items shall be displayed at the Operator's Terminal:
    - a. Commanded status of fan.
    - b. Operational status of fan via current sensor.
    - c. Position of associated motor operated dampers via end-switch.

### **3.03 KITCHEN EXHAUST HOODS / KITCHEN MAKE-UP AIR UNITS**

- A. Exhaust fans serving Kitchen Range Hoods shall be controlled manually via a hood-mounted control system.
- B. Each exhaust fan and tempered make-up air unit shall be controlled via a variable-exhaust flow controller, as well as a BAS controller for integration into the building control system.. The controller shall independently vary the exhaust fan and supply air system via the corresponding variable frequency drives in response to the sensor reading in the hood exhaust for both temperature and particulate exhaust rate. A local controller shall be provided for BAS integration and control of the makeup air system.
- C. An offset of supply air / exhaust air shall be maintained such that supply airflow rate is always 80% of exhaust airflow rate.
- D. See kitchen equipment plans for coordination and additional BAS requirements.
- E. Provide a current sensor for each fan (supply and exhaust) to show operational status.
- F. The following items shall be displayed at the Operator's Terminal:
  - 1. Operational status of fans via VFD feedback.
  - 2. Burner status of makeup air unit.
  - 3. Discharge air temperature of makeup air unit.
  - 4. VFD power level for each fan (as a percentage)

**3.04 ELECTRIC RADIATION AND CONVECTORS**

- 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.

**3.05 SINGLE ZONE PACKAGED ROOFTOP UNITS WITH NATURAL GAS HEAT AND CENTRAL ENERGY RECOVERY**

- A. Each unit shall be controlled by an individual DDC Controller. The DDC Controller shall be wired to a space temperature sensor, space-level CO2 sensor, space humidity sensor, discharge air temperature sensor, return air temperature sensor, space differential pressure sensor, damper motors, and the contacts to the factory-mounted unit control system controlling the compressor(s), hot-gas bypass, hot-gas reheat, and gas train combustion equipment. See typical RTU controls schematic for additional I/O points.
- B. Cooling Mode:
  - 1. During the programmed occupied mode, the supply fan shall run continuously with the outside air damper open to the minimum position (10% outdoor air unless otherwise shown on Schedule).
    - a. The fan modulates to maintain space temperature while maintaining the discharge air setpoint (normally 55.0 deg. F - 60.0 deg. F). As the cooling load decreases, the fans will modulate down to minimum speed. As the space temperature continues to fall below the cooling setpoint by 1.0 deg. F (adj.) and remains at minimum speed for a period of time (default=10 minutes adj.) the fan will remain at minimum speed and enter into a discharge air reset mode. As the space temperature continues to drop toward the space occupied heating setpoint, the discharge air setpoint is reset between the "normal" discharge air cooling setpoint and the discharge air heating setpoint.
    - b. The fan will remain at minimum speed until the space temperature exceeds the cooling setpoint +1.0 deg. F for 10 minutes (adj.). At that point it will revert to its fan modulating mode with its discharge setpoint equal to its Discharge Air Cooling setpoint.
    - c. When in the occupied mode, the outdoor-air damper shall modulate to maintain the current outdoor airflow at setpoint as read by an outdoor airflow monitoring station. The BAS shall calculate and reset this outdoor airflow setpoint based on the current ventilation requirements based on field mounted CO2 sensor. The amount of outside air will be increased above the minimum setting on a rise in return air CO2 above the setpoint of 750 PPM (adjustable). On a return to setpoint the reverse occurs. Upon a rise in CO2 level above 1500 PPM, a high CO2 level will be displayed at the BAS workstation.
    - d. Setpoints are adjustable at the BAS workstation. As the outdoor air damper and supply air fan adjusts, the return exhaust fan shall automatically adjust it's speed to maintain a constant static pressure within the space (0.3" WC, adjustable).
  - 2. The DX cooling shall stage and modulate to maintain the discharge air temperature setpoint in cooling mode. If economizing is enabled the outside air damper shall also modulate to maintain the discharge air temperature setpoint.

- a. As noted in paragraph B-1-a above, if cooling or heating is required and the fan is at minimum airflow then the DAT setpoint shall be reset up or down to accommodate space requirements.
  3. For units equipped with an outdoor air economizer: The DDC Controller shall receive input from the Global Enthalpy Sensor. If the enthalpy of the outdoor air is lower than the defined minimum level (user adjustable) the mixing box economizer sequence shall be activated upon a call for cooling. The outside air damper shall never close past the minimum position during the occupied period.
  4. When dehumidification is required as sensed by the factory-provided humidistat (setpoint, 60% RH, adjustable), the hot-gas reheat system will be engaged and follow the factory-programmed sequence.
- C. Heating Mode:
1. During the programmed occupied mode, the supply fan shall run continuously with the outside air damper open to the minimum position (10% outdoor air unless otherwise shown on Schedule).
    - a. The supply fan shall modulate airflow to maintain space temperature. The supply fan shall not modulate below the minimum OA ventilation rate required in the space. If cooling or heating is required and the fan is at minimum airflow then the DAT setpoint shall be reset up or down to accommodate space requirements. When the space temperature decreases to 1.0 deg. F below the heating setpoint, the fan will ramp up to 100% and the heat will be enabled. When the space temperature exceeds the heating setpoint +1.0 deg. F the heat will be disabled and the fan will ramp down to its minimum speed. Reset of the discharge air setpoint will occur every 5-10 minutes (adj.)
    - b. When the space temperature rises above the occupied cooling setpoint the mode shall transition to cooling. When the space temperature falls below the occupied heating setpoint the mode shall transition to heating. When the space temperature is above the occupied cooling setpoint or below the occupied heating setpoint the mode shall remain in its last state. If the space temperature sensor fails the mode shall remain in its last state and an alarm shall be annunciated at the BAS. If the local and communicated setpoints fail the controller shall disable the supply fan and an alarm shall be annunciated at the BAS.
    - c. When in the occupied mode, the outdoor-air damper shall modulate to maintain the current outdoor airflow at setpoint. The BAS shall calculate and reset this outdoor airflow setpoint based on the current ventilation requirements based on field mounted CO2 sensor. The amount of outside air will be increased above the minimum setting on a rise in return air CO2 above the setpoint of 750 PPM (adjustable). On a return to setpoint the reverse occurs. Upon a rise in CO2 level above 1500 PPM, a high CO2 level will be displayed at the BAS workstation.
    - d. Setpoints are adjustable at the BAS workstation. As the outdoor air damper and supply air fan adjusts, the return exhaust fan shall automatically adjust it's speed to maintain a constant static pressure within the space (0.3" WC, adjustable).
  2. The gas-fired heating section shall modulate to maintain the discharge air temperature setpoint as defined on the unit schedule. Temperatures shall be user-adjustable. As noted in paragraph C-1-a above, If cooling or heating is required and the fan is at minimum airflow then the DAT setpoint shall be reset up or down to accommodate space requirements.
- D. Energy Recovery Wheel Operation
1. FOR UNITS EQUIPPED WITH AN ENERGY RECOVERY WHEEL: The AHU shall be in cooling recovery mode when the outdoor air temperature is greater than the space temperature and higher than the energy wheel enable setpoint (system economizer setpoint temperature). When the wheel is enabled, both outdoor & exhaust air bypass



- dampers shall be closed, outdoor air damper shall be at minimum, return air damper shall be open, and cooling shall be enabled. In cooling the recovery wheel shall be disabled when the outdoor air temperature is less than the space temperature and both outdoor & exhaust air bypass dampers shall be open.
2. The AHU shall be in heating recovery mode when the outdoor air temperature is less than the space temperature and less than the energy wheel enable setpoint and the supply air temperature is less than the discharge air setpoint. When heat recovery is enabled the wheel shall be enabled as the first stage of heat, the outdoor air damper shall be at minimum, the outdoor & bypass recovery bypass dampers shall be open, and the unit heat shall be disabled. On a continued call for heat the second stage is enabled, the outdoor recovery bypass damper shall close, and the exhaust recovery bypass damper shall modulate to maintain the space temperature setpoint. If additional heat is required the third stage is enabled, the return air damper shall be open, both recovery bypass dampers shall be closed, and the unit heat shall be enabled.
  3. If the outdoor air temperature drops below the outdoor air frost protection setpoint (adj.), the outdoor air bypass damper shall modulate to maintain the exhaust-side leaving temperature at setpoint. If the outdoor air bypass damper reaches 100% open for 5 minutes (adj.), the wheel shall be turned off to prevent frosting and an alarm shall be annunciated.
- E. Cafeteria Unit Pressurization
1. For the unit serving the cafeteria, provide a space-level differential air pressure sensor between the cafeteria and kitchen areas. Unit to maintain a constant 0.5" W.C. positive pressure from the cafeteria to the kitchen by varying the variable frequency drive on the exhaust fan in the cafeteria unit.
- F. Dehumidification mode: On a rise in humidity levels as determined by space humidity sensors the following shall occur. The cooling and HGRH coils shall modulate capacity to satisfy the space-mounted humidity sensor. On a continued rise in space humidity the BAS shall de-energize the ERV and close outside air dampers. On a decrease in space humidity, the reverse shall occur. The cooling sequence shall take precedence and dehumidification sequence shall be separately engaged once cooling is satisfied.
- G. Unoccupied Mode:
1. During the programmed un-occupied mode, the supply fan, compressor, gas train, and dampers for shall be cycled / modulated to maintain the un-occupied setpoints (55 degrees in Heating mode, 80 degrees in Cooling mode, both adjustable). Unless required for economizer cycle, the outside air damper shall remain closed.
- H. All setpoints and shall be adjustable at the BAS workstation.
- I. Provide a current sensor on one phase of power feeding each supply fan, exhaust fan, heat wheel, and compressor for status indication at the Operator's Terminal.
- J. If the discharge temperature fails to rise to a programmed minimum temperature during a call for heating; a low temperature alarm shall be activated at the Operator's Terminal. If the discharge temperature fails to fall to a programmed minimum temperature on a call for mechanical cooling, a high temperature alarm shall be activated at the Operator's Terminal.
- K. Duct smoke detectors shall be provided in supply and return ductwork, with connection to the fire alarm control panel and associated rooftop unit for fan shutdown.
- L. The following items shall be displayed at the Operator's Terminal:
1. Space temperature.
  2. Space temperature setpoint.
  3. Space humidity.
  4. Space humidity setpoint.
  5. Low Space temperature alarm.

6. High Space temperature alarm.
7. Discharge air temperature.
8. Discharge air temperature setpoint.
9. Return air temperature.
10. Outside air temperature, humidity and enthalpy.
11. Economizer enthalpy setpoint.
12. Space CO2 level.
13. Space CO2 level setpoint.
14. Space high CO2 level alarm: "1500 PPM", adjustable.
15. Supply fan operational status and speed (percentage)
16. Commanded status of supply fan.
17. Exhaust fan operational status and speed (percentage)
18. Commanded status of exhaust fan.
19. Heat Wheel operational status via current sensor.
20. Commanded status of heat wheel.
21. Commanded status of compressor(s).
22. Commanded status of gas-train.
23. Commanded position of dampers.
24. Diagram showing the layout of the unit with major components and dynamic temperatures shown where temperature sensors exist in the system.

### **3.06 ELECTRIC UNIT HEATERS AND ELECTRIC CABINET HEATERS**

- A. User-adjustable temperature maintained by DDC controller and local thermostat set at 70 degrees F (adjustable) maintains constant space temperature by cycling unit fan motor and electric heating element.
- B. The following items shall be displayed at the Operator's Terminal:
  1. Temperature Setpoint.
  2. Actual space temperature.
  3. Commanded status of gas train.
  4. Commanded status of fan motor.

### **3.07 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).

### **3.08 GAS FIRED UNIT HEATERS**

- A. User-adjustable temperature maintained by DDC controller and local thermostat set at 70 degrees F (adjustable) maintains constant space temperature by cycling unit fan motor and associated gas train.
- B. The following items shall be displayed at the Operator's Terminal:
  - 1. Temperature Setpoint.
  - 2. Actual space temperature.
  - 3. Commanded status of gas train.
  - 4. Commanded status of fan motor.

### **3.09 VARIABLE REFRIGERANT VOLUME HEAT PUMP 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 manufacturer factory 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. 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.
  - 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. On a drop in space temperature below the setpoint (70 degrees, adjustable), the manufacturer central controller shall energize the central compressor to 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 fall in space temperature the refrigerant capacity control valve shall modulate closed.
  - 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 space.
    - c. Operational status of each fan-coil unit (heating, cooling, off, fan speed).
    - 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
  - 4. Unoccupied Mode: During the programmed un-occupied mode, the supply fan, compressors, and thermal expansion valves shall be cycled / modulated to maintain the un-occupied setpoints (55 degrees in Heating mode, 80 degrees in Cooling mode, both adjustable).
- C. Each terminal unit (fan coil) shall be controlled by the factory-provided wall-mounted controller. The controller shall be a flat-plate type sensor with no display or adjustment.

- D. Where multiple units serve the same zone, a factory-supplied control twinning kit will be provided to allow for a single temperature sensor to control both zones.
- E. For all public corridors, restrooms, and vestibules, provide stainless-steel flat-plate type temperature sensors with no setpoint adjustment.

### **3.10 ENERGY RECOVERY VENTILATORS (ERV) FOR VRF SYSTEMS**

- A. Supply air units and ERV's 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 by the heat recovery unit is in the occupied mode the unit shall be energized.
  - 1. The unit exhaust and outside air isolation dampers shall open.
  - 2. Provide proof of airflow for each fan and provide fan failure alarms.
  - 3. Provide temperature indication of the supply and exhaust inlet and leaving air.
  - 4. Duct smoke detectors shall be provided in supply and return ductwork with connection to fire alarm control panel and associated ERV for fan shutdown.
  - 5. The electric heating coil shall be energized when required to maintain a minimum discharge air (supply air) temperature of 60 degrees to the units.
- D. The following items shall be displayed at the operators workstation:
  - 1. Discharge temperature downstream of ERV.
  - 2. Discharge temperature downstream of associated duct heating coil.
  - 3. Return air temperature.
  - 4. Outside air temperature, humidity and enthalpy.
  - 5. Fan operational status via current sensor.
  - 6. Commanded status of fan.
  - 7. Commanded status of heating coils (as applicable).
  - 8. Commanded status of gas-train (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.

### **3.11 ENERGY AND WATER METERING**

- A. The incoming electrical feeds and water feeds for the building will be provided with meters for monitoring of utility usage.
  - 1. Electrical Monitoring: BAS system shall receive input from a factory-provided power meter integrated into the main switchgear for the facility.
    - a. Monitor and trend:
      - 1) Energy usage
      - 2) Power demand
      - 3) Reactive Power (KVAR)
      - 4) Phase loss
      - 5) Any error codes/failures from the meter system.
    - b. Alarms:
      - 1) Power failure. Send alarm to end-user as specified by Owner.
  - 2. Water monitoring: BAS system shall receive a pulse-output signal from the contractor-provided meter.
    - a. Monitor and trend:
      - 1) Total water usage

- 2) Daily water usage
- 3) Daily average (7 day time window, user adjustable)
- b. Alarms:
  - 1) Breach of daily average trend by more than 50%. Send alarm to end-user as specified by Owner.

### **3.12 SITE LIGHTING CONTROL**

- A. Provide schedule-based control of site lighting and all exterior lighting. Control via 365 day calendar with automatic adjustment for annual solar variance as well as daylight savings time. Control will be via contactor on the site lighting power circuit. See electrical drawings for locations and number of contactors required.
- B. Each zone shall be able to be set independently for schedule.
  - 1. Display current status of contactor at display screen of operator's workstation.

### **3.13 CUSTOMIZED LOAD SHEDDING CONTROL:**

- A. The system shall provide a customizable, single-point control on the home screen that will allow the Owner to shed power load from the facility. Load shedding shall be achieved as follows:
  - 1. Global Cooling Setpoint Reset - Reset all space temperature setpoints to their night-setback temperatures. This shall not put the building into night setback mode, as ventilation units must continue to operate during this time.
    - a. NOTE: The Nurse's Suite shall be exempt from this reset option.

**END OF SECTION**

**SECTION 23 21 13**  
**HYDRONIC PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Equipment Drains and Overflows

**1.02 RELATED REQUIREMENTS**

- A. Section 07 84 00 - Firestopping.
- B. Section 08 31 00 - Access Doors and Panels.
- C. Section 09 90 00 - Painting and Coating.
- D. Section 22 05 48 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- E. Section 22 05 53 - Identification for Plumbing Piping and Equipment.
- F. Section 22 07 19 - Plumbing Piping Insulation.
- G. Section 22 0516 - Expansion Fittings and Loops for Plumbing Piping.
- H. Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping.
- I. Section 23 05 48 - Vibration and Seismic Con. for Equipment.
- J. Section 23 05 53 - Identification for HVAC Piping and Equipment.
- K. Section 23 07 19 - HVAC Piping Insulation.
- L. Section 23 21 14 - Hydronic Specialties.
- M. Section 23 25 00 - HVAC Water Treatment: Pipe cleaning.
- N. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

**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 B31.9 - Building Services Piping.
- F. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers.
- G. ASME B31.5 - Refrigeration Piping and Heat Transfer Components; The American Society of Mechanical Engineers.
- H. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers (ANSI/ASME B31.9).
- I. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- J. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- K. ASTM B32 - Standard Specification for Solder Metal.
- L. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
- M. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric).

- N. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- O. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
- P. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
- Q. ASTM D2310 - Standard Classification for Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
- R. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- S. ASTM D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- T. ASTM D2680 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.
- U. ASTM D2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
- V. ASTM D2855 - Standard Practice for the Two-Step (Primer & Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
- W. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
- X. ASTM F876 - Standard Specification for Crosslinked Polyethylene (PEX) Tubing.
- 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 C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast.
- AE. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

#### **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 ASME B31.9 unless indicated otherwise.

#### **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. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- C. 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.

**1.07 REGULATORY REQUIREMENTS**

- A. Conform to ASME B31.9 code for installation of piping system.

**1.08 DELIVERY, STORAGE, AND HANDLING**

- A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- B. 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.

**PART 2 PRODUCTS****2.01 EQUIPMENT DRAINS AND OVERFLOWS**

- A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), 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. Conform to ASME B31.9.
- C. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
- D. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
- E. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
- F. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
- G. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- H. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
- I. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- J. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
- K. Wall Support for Hot Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.



- L. Vertical Support: Steel riser clamp.
- M. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- N. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- O. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- P. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- Q. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
- R. 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.
- S. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

### **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 using jointing system specified.
- D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

#### **3.02 INSTALLATION**

- A. All condensate installed above inaccessible ceilings, behind walls, or exterior to building shall be provided as copper.
- B. Install in accordance with manufacturer's instructions.
- C. Install heating water, chilled water, dual-temperature, and condenser water piping to ASME B31.9 requirements.
- D. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- E. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- F. Install piping to conserve building space and to avoid interfere with use of space.
- G. Group piping whenever practical at common elevations.
- H. Sleeve pipe passing through partitions, walls and floors.
- I. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- J. Slope piping and arrange to drain at low points.
- K. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16.
  - 1. Flexible couplings may be used in header piping to accommodate thermal growth, thermal contraction in lieu of expansion loops.
- L. 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.
- M. 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.
- N. 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.
- O. 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.
- P. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 31 00.
- Q. Use eccentric reducers to maintain top of pipe level.
- R. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- S. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting. Refer to Section 09 90 00.
- T. Install valves with stems upright or horizontal, not inverted.

### 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**

**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 23 82 16 - 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 (I-P) - Flow Capacity Rating of Suction-Line Filters and Suction-Line Filter-Driers.
- D. AHRI 750 - Thermostatic Refrigerant Expansion Valves.
- E. AHRI 760 - 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 the State in which the Project is located.

#### **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 REFRIGERANT**

- A. Refrigerant: See Schedules

**2.03 MOISTURE AND LIQUID INDICATORS**

- A. Manufacturers:
  - 1. Henry Technologies: [www.henrytech.com/#sle](http://www.henrytech.com/#sle).
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).
  - 3. Sporlan Valve Company: [www.sporlan.com/#sle](http://www.sporlan.com/#sle).
- 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.

**2.04 VALVES**

- A. Manufacturers:
  - 1. Hansen Technologies Corporation: [www.hantech.com/#sle](http://www.hantech.com/#sle).
  - 2. Henry Technologies: [www.henrytech.com/#sle](http://www.henrytech.com/#sle).
  - 3. Danfoss Flomatic: [www.flomatic.com/#sle](http://www.flomatic.com/#sle).
- 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.

**2.05 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.

**2.06 CHECK VALVES**

- A. Manufacturers:
  - 1. Hansen Technologies Corporation: [www.hantech.com/#sle](http://www.hantech.com/#sle).
  - 2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).
  - 3. Sporlan Valve Company: [www.sporlan.com/#sle](http://www.sporlan.com/#sle).
  - 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.

## **2.07 PRESSURE REGULATORS**

- A. Manufacturers:
  1. Hansen Technologies Corporation: [www.hantech.com/#sle](http://www.hantech.com/#sle).
  2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).
  3. Sporlan Valve Company: [www.sporlan.com/#sle](http://www.sporlan.com/#sle).
  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.

## **2.08 PRESSURE RELIEF VALVES**

- A. Manufacturers:
  1. Hansen Technologies Corporation: [www.hantech.com/#sle](http://www.hantech.com/#sle).
  2. Henry Technologies: [www.henrytech.com/#sle](http://www.henrytech.com/#sle).
  3. Sherwood Valve/Harsco Corporation: [www.sherwoodvalve.com/#sle](http://www.sherwoodvalve.com/#sle).
  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.

## **2.09 FILTER-DRIERS**

- A. Manufacturers:
  1. Flow Controls Division of Emerson Electric: [www.emersonflowcontrols.com/#sle](http://www.emersonflowcontrols.com/#sle).
  2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).
  3. Sporlan Valve Company: [www.sporlan.com/#sle](http://www.sporlan.com/#sle).
  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 (I-P).
  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.

## **2.10 SOLENOID VALVES**

- A. Manufacturers:

1. Flow Controls Division of Emerson Electric: [www.emersonflowcontrols.com/#sle](http://www.emersonflowcontrols.com/#sle).
  2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).
  3. Sporlan Valve Company: [www.sporlan.com/#sle](http://www.sporlan.com/#sle).
- 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.

## **2.11 EXPANSION VALVES**

- A. Manufacturers:
1. Flow Controls Division of Emerson Electric: [www.emersonflowcontrols.com/#sle](http://www.emersonflowcontrols.com/#sle).
  2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).
  3. Sporlan Valve Company: [www.sporlan.com/#sle](http://www.sporlan.com/#sle).
- 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.

## **2.12 ELECTRONIC EXPANSION VALVES**

- A. Manufacturers:
1. Danfoss Automatic Controls: [www.danfoss.com](http://www.danfoss.com).
  2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).
  3. Sporlan Valve Company: [www.sporlan.com/#sle](http://www.sporlan.com/#sle).
- 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.

## **2.13 RECEIVERS**

- A. Manufacturers:
1. Henry Technologies: [www.henrytech.com/#sle](http://www.henrytech.com/#sle).
  2. Parker Hannifin/Refrigeration and Air Conditioning: [www.parker.com/#sle](http://www.parker.com/#sle).

3. Sherwood Valve/Harsco Corporation: [www.sherwoodvalve.com/#sle](http://www.sherwoodvalve.com/#sle).
- B. Internal Diameter 6 inch and Smaller:
  1. AHRI 495, UL listed, steel, brazed; 400 psi maximum pressure rating, with tapings 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 tapings for liquid inlet and outlet valves, pressure relief valve, and magnetic liquid level indicator.

## **2.14 FLEXIBLE CONNECTORS**

- A. Manufacturers:
  1. Circuit Hydraulics, Ltd: [www.circuit-hydraulics.co.uk](http://www.circuit-hydraulics.co.uk).
  2. Flexicraft Industries: [www.flexicraft.com/#sle](http://www.flexicraft.com/#sle).
  3. Penflex: [www.penflex.com/#sle](http://www.penflex.com/#sle).
- 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.
- C. Kitchen hood ductwork.

**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, Culvert Pipe and (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. SMACNA (KVS) - Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines.
- S. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.
- T. IECC 2012 - International Energy Conservation Code - Duct construction 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. MANDATORY Test Reports: 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. Leakage rate shall not exceed 4.0 in that equation.
- 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. 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.
- O. Grease Exhaust: 1 inch w.g. pressure class, stainless steel.
  - 1. Construct of 18 gage stainless steel.
  - 2. Construction:
    - a. Liquid tight with continuous external weld for all seams and joints.
    - b. Where ducts are not self draining back to equipment, provide low point drain pocket with copper drain pipe to sanitary sewer.
  - 3. Access Doors:
    - a. Provide for duct cleaning inside horizontal duct at drain pockets, every 20 feet and at each change of direction.
    - b. Use same material and thickness as duct with gaskets and sealants rated 1500 degrees F for grease tight construction.



4. Surface Burning Characteristics: Flame spread of zero, smoke developed of zero, when tested in accordance with ASTM E 84.

### **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, Minimum R-6.
    - 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.
  1. Manufacturers:

### **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.

## **2.06 KITCHEN HOOD EXHAUST DUCTWORK**

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards, SMACNA Kitchen Ventilation Systems and Food Service Equipment Fabrication & Installation Guidelines and NFPA 96.

## **2.07 DISHWASHER EXHAUST DUCTWORK**

- A. Fabricate dishwasher head exhaust ducts with 18 gauge stainless steel. Weld and flange seams and joints.

# **PART 3 EXECUTION**

## **3.01 INSTALLATION**

- A. Provide flexible duct connectors at all motorized equipment.
- B. Install, support, and seal ducts in accordance with SMACNA HVAC Duct Construction Standards.
- C. Install in accordance with manufacturer's instructions.
- D. Kitchen Hood Exhaust: Provide residue traps at base of vertical risers with provisions for clean out.
- E. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- F. Install and seal metal and flexible ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- G. 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.
- H. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- I. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.
- J. Use double nuts and lock washers on threaded rod supports.
- K. Tape joints of PVC coated metal ductwork with PVC tape.
- L. Connect terminal units to supply ducts with one foot maximum length of flexible duct. Do not use flexible duct to change direction.
- M. 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.
- N. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- O. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
- P. Use stainless steel for ductwork exposed to view and stainless steel or carbon steel for ducts where concealed.
- Q. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- R. At exterior wall louvers, seal duct to louver frame and install blank-out panels as required.

**3.02 RANGE HOOD EXHAUST DUCT INSTALLATIONS**

- A. Install ducts to allow for thermal expansion of ductwork through 2000 deg F temperature range.
- B. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for clean out.
- C. Install ducts without dips or traps that may collect residues, unless traps have continuous or automatic residue removal.
- D. Install access openings at each change in direction and at 50-foot intervals; locate on sides of duct a minimum of 1-1 1/2 inches from bottom; and fit with grease-tight covers of same material as duct.
- E. Do not penetrate fire-rated assemblies.

**3.03 CLEANING AND TESTING**

- A. Conduct required duct-leakage testing for all ductwork as defined within this specification and otherwise noted in the contract documents.

**3.04 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: Stainless Steel.
  - 7. Dishwasher 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): 2 inch.
  - 3. Return and Relief: 1 inch.
  - 4. General Exhaust: 1 inch.
  - 5. Outside Air Intake: 2 inch.

**END OF SECTION**

**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 6000 - 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/#sle](http://www.krueger-hvac.com/#sle).
  - 2. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 3. Titus: [www.titus-hvac.com/#sle](http://www.titus-hvac.com/#sle).
  - 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/#sle](http://www.louvers-dampers.com/#sle).
  - 2. Nailor Industries Inc: [www.nailor.com/#sle](http://www.nailor.com/#sle).
  - 3. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 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/#sle](http://www.louvers-dampers.com/#sle).
  - 2. Nailor Industries Inc: [www.nailor.com/#sle](http://www.nailor.com/#sle).
  - 3. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 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. Provide end switches to indicate damper position. 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. 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/#sle](http://www.nailor.com/#sle).
  - 2. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 3. SEMCO Incorporated: [www.semcoinc.com/#sle](http://www.semcoinc.com/#sle).
  - 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/#sle](http://www.louvers-dampers.com/#sle).
  - 2. Nailor Industries Inc: [www.nailor.com/#sle](http://www.nailor.com/#sle).
  - 3. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 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. Lead 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/#sle](http://www.louvers-dampers.com/#sle).
  - 2. Nailor Industries Inc: [www.nailor.com/#sle](http://www.nailor.com/#sle).
  - 3. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 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 120V electric actuator.

## **2.11 VOLUME CONTROL DAMPERS**

- A. Manufacturers:
  - 1. Louvers & Dampers, Inc: [www.louvers-dampers.com/#sle](http://www.louvers-dampers.com/#sle).
  - 2. Nailor Industries Inc: [www.nailor.com/#sle](http://www.nailor.com/#sle).
  - 3. Ruskin Company: [www.ruskin.com/#sle](http://www.ruskin.com/#sle).
  - 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 access doors at any location where dampers are concealed above inaccessible ceilings.
- C. Provide flexible duct connectors at expansion joints and at all connections to motorized equipment.
- D. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- E. 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.
- F. Provide duct test holes where indicated and required for testing and balancing purposes.
- G. 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.
- H. 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.
- I. Demonstrate re-setting of fire dampers to Owner's representative.
- J. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- K. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment; see Section 22 05 48.
- L. For fans developing static pressures of 5.0 inches and over, cover flexible connections with leaded vinyl sheet, held in place with metal straps.
- M. 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.
- N. Use splitter dampers only where indicated.
- O. Provide balancing dampers on high velocity systems where indicated. Refer to Section 23 36 00 - Air Terminal Units.
- P. 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. Kitchen Ventilation Systems / Roof exhausters.
- B. Roof ventilators.
- C. Wall exhausters.
- D. Inline centrifugal fans.
- E. Ceiling exhaust fans.

**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 (DIR) - [Directory of] Products Licensed Under AMCA International Certified Ratings Program; Air Movement and Control Association International, Inc..
- E. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
- F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- G. NEMA MG 1 - Motors and Generators.
- H. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- I. 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 6000 - 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/#sle](http://www.greenheck.com/#sle).
- B. Loren Cook Company: [www.lorencook.com/#sle](http://www.lorencook.com/#sle).
- C. PennBarry: [www.pennbarry.com/#sle](http://www.pennbarry.com/#sle).
- D. American Coolair/ILG: [www.coolair.com](http://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, KITCHEN VENTILATION SYSTEMS**

- 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 with junction box and wire whip to open damper upon activation of exhaust fan, 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.
- J. Make-up Air unit:
  - 1. Variable-volume direc-fired natural gas makeup air unit with spark ignition, discharge temperature control, and factory disconnect.

#### **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: Motorized with junction box and wire whip to open upon activation of exhaust fan, 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 with junction box and wire whip to open upon activation of exhaust fan.
- 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. Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resilient mounted motor, motorized backdraft damper with junction box and wire whip to energize damper upon activation of fan.
- B. Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted switch.
- C. 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.

### **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 exhausters fans and as indicated.

**END OF SECTION**

**SECTION 23 37 00**  
**AIR OUTLETS AND INLETS**

**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Diffusers.
- B. Registers/grilles.
- C. Fabric air distribution devices.
- D. Door grilles.
- E. Louvers.
- F. 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.
- E. Fabric Duct Dispersion System
  - 1. Product Data: Submit manufacturer's specifications on materials and manufactured products used for work of this section.
  - 2. Building Code Data: Submit UL file number under which product is Classified by Underwriter's Laboratories for both NFPA 90-A and UL 2518.
  - 3. Provide detailed drawings confirming configuration of Textile Dispersion System (diameter, lengths, airflow, pressure, and textile permeability).
  - 4. Provide detailed installation instructions for components to be installed.
  - 5. Provide warranty and maintenance documentation.

**1.05 WARRANTY**

- A. Manufacturer must provide a 10 Year Product Warranty for products supplied for the fabric portion of this system as well as a Design and Performance Warranty.

**1.06 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.
- C. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum [five] years of documented experience.

- D. Fabric Duct Dispersion System
  - 1. Building Codes and Standards:
    - a. Product must be Classified by Underwriter's Laboratories in accordance with the 25/50 flame spread / smoke developed requirements of NFPA 90-A and UL 2518. Also Classified by UL-C (Canada) S102.2, BS 5867 Part 2, 1980; GB8624-2006.
    - b. All product sections must be labeled with the logo and classification marking of Underwriter's Laboratories.
  - 2. Design & Quality Control
    - a. Manufacturer must have documented design support information including duct sizing; vent, orifice, and/or nozzle location; vent, orifice, and/or nozzle sizing; length; and suspension. Parameters for design, including maximum air temperature, velocity, pressure and textile permeability, shall be considered and documented.

#### **1.07 DELIVERY, STORAGE AND HANDLING:**

- A. Protect textile air dispersion system and SkeleCore Pull-Tight components from damage during shipping, storage, and handling.
- B. Where possible, store products inside and protect from weather. Where necessary to store outside, store above grade and enclose with a vented waterproof wrapping

#### **1.08 MOCK-UP**

- A. Provide mock-up of typical interior and 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](http://www.carnes.com).
- B. Krueger: [www.krueger-hvac.com/#sle](http://www.krueger-hvac.com/#sle).
- C. Price Industries: [www.price-hvac.com/#sle](http://www.price-hvac.com/#sle).
- D. Titus: [www.titus-hvac.com/#sle](http://www.titus-hvac.com/#sle).
- E. Tuttle and Bailey: [www.tuttleandbailey.com](http://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. Fabrication: Aluminum with baked enamel off-white finish.
- D. 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. Fabrication: Steel backpan with aluminum frame and baked enamel off-white finish.

- D. 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 Architect 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. Fabrication: Aluminum extrusions, with factory off-white enamel, baked enamel, or prime coated finish as indicated on drawings or selected by architect.
- D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.
- E. Gymnasiums: 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 x 1/2 x 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. Fabrication: Aluminum extrusions, with factory off-white enamel, baked enamel, prime coat or clear lacquer finish as indicated on drawings or selected by architect.
- D. Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.
- E. 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. Fabrication: Aluminum extrusions, with factory off-white enamel, baked enamel, prime coated or clear lacquer finish as indicated on drawings or selected by architect.
- D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.
- E. 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 x 1/2 x 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 FABRIC AIR DISTRIBUTION DEVICES**

- A. Manufacturers:
  - 1. DuctSox.
  - 2. KE Fibertec.
  - 3. Fabric Air.
  - 4. Substitutions: To request a substitution for products not listed, provide complete submittal package to engineer indicating any and all deviations between basis of design and proposed substitution. Substitution request must be completely submitted to engineer not less than 10 business days prior to bid opening for review.
- B. SkeleCore Pull-Tight System: Air diffusers shall be constructed with both internal retention and external tensioning.
  - 1. System shall consist of internal tensioning baskets with cable or track stops that externally tension the system off of the suspension system selected below along with 360 degree internal retention hoops that are spaced 5' on center between tensioning baskets.
  - 2. Tensioning baskets are designed to self-lock when tension is applied to the system.
  - 3. All straight sections utilize both internal retention hoops and external tensioning with the use of the tension baskets, all fittings (crosses, elbows, reducers, and tees) utilize internal retention hoops.
  - 4. Distance between consecutive tensioning baskets should not be more than 40'.
  - 5. System shall be installed with a one row suspension system located 1.5" above top-dead-center of the textile system.
  - 6. System attachment to cable or U-Track shall be made using Gliders spaced no further than 12 inches apart.
  - 7. One row suspension options (must specify if multiple on same project)
    - a. U-Track suspension hardware to include 8' sections of aluminum track, aluminum splice connectors, track endcaps and vertical cable support kits - consisting of a length of cable with cable connectors. Radius aluminum track must be included for all horizontal/flat radius sections.
      - 1) U-Track suspension options (must specify if multiple on same project)
        - (a) Galvanized steel cable

- C. Textile
  - 1. Verona
    - a. Textile Construction: Filament/filament twill polyester, fire retardant in accordance with UL 2518.
    - b. Air Permeability: 2 (+2/-1) CFM/ft<sup>2</sup> per ASTM D737, Frazier
    - c. Weight: 6.8 oz. /yd<sup>2</sup> per ASTM D3776
    - d. Warranty: 10 years
  - 2. Textile Color
    - a. Standard: blue, white, tan, red, green, silver, black
- D. Textile System Fabrication Requirements
  - 1. Textile system to be constructed in modular lengths (zippered) with proper radial securing clips (inlets, endcaps, and mid-sections) and top access zippers for tension lock attachments.
  - 2. Integrated air dispersion shall be specified and approved by manufacturer. (select only those that apply)
    - a. Linear Vents
      - 1) Air dispersion accomplished by linear vent and permeable fabric. Linear vents must be sized in 1 CFM per linear foot increments (based on .5" SP), starting a 1 CFM through 90 CFM per linear foot. Linear vent is to consist of an array of open orifices rather than a mesh style vent to reduce maintenance requirements of mesh style vents. Linear vents should also be designed to minimize dusting on fabric surface.
      - 2) Size of vent openings and location of linear vents to be specified and approved by manufacturer.
  - 3. Inlet connection to metal duct via fabric draw band with anchor patches as supplied by manufacturer. Anchor patches to be secured to metal duct via. zip screw fastener - supplied by contractor.
  - 4. Inlet connection includes zipper for easy removal / maintenance.
  - 5. Lengths to include required intermediate zippers as specified by manufacturer.
  - 6. System to include Adjustable Flow Devices to balance turbulence, airflow and distribution as needed. Flow restriction device shall include ability to adjust the airflow resistance from 0.06 - 0.60 in w.g. static pressure.
  - 7. End cap includes zipper for easy maintenance.
  - 8. Each section of the textile shall include identification labels documenting order number, section diameter, section length, piece number, code certifications and other pertinent information.
- E. Design Parameters
  - 1. Textile air diffusers shall be designed from 0.25" water gage minimum to 3.1" maximum, with 0.5" as the standard.
  - 2. Textile air diffusers shall be limited to design temperatures between 0 degrees F and 180 degrees F (-17.8 degrees C and 82 degrees C).
  - 3. System overall design; diameter, length, airflow, operating static pressure and dispersion shall be designed or approved by the manufacturer.
  - 4. Do not use textile diffusers in concealed locations.
  - 5. Use textile air dispersion systems only for positive pressure air distribution components of the mechanical ventilation system.

## 2.12 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.

**2.13 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 Architect from manufacturer's standard range. Provide Kynar / Hylar 500 Finish.
- C. Fabrication: 12 gage, 0.1046 inch thick extruded aluminum, welded assembly, with factory prime coat finish.
- D. 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.
- E. Mounting: Furnish with exterior angle flange, screw holes in jambs or masonry strap anchors for installation.

**2.14 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 9 x 9 inch.

**PART 3 EXECUTION****3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Insulate opposite side of air distribution for all supply diffusers or registers (top-side or back-side).
- C. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- D. Install diffusers to ductwork with air tight connection.
- E. 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.
- F. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 90 00.
- G. Fabric Duct Dispersion System
  - 1. Installation of Textile Air Dispersion System
    - a. Install chosen suspension system in accordance with the requirements of the manufacturer. Instructions for installation shall be provided by the manufacturer with product.
  - 2. Cleaning and Protection
    - a. Clean air handling unit and ductwork prior to the DuctSox system unit-by-unit as it is installed. Clean external surfaces of foreign substance which may cause corrosive deterioration of facing.
    - b. Temporary Closure: At ends of ducts which are not connected to equipment or distribution devices at time of ductwork installation, cover with polyethylene film or other covering which will keep the system clean until installation is completed.
    - c. If DuctSox systems become soiled during installation, they should be removed and cleaned following the manufacturers standard terms of laundry.

**3.02 AIR OUTLET AND INLET SCHEDULE**

- A. See Drawings

**END OF SECTION**



**SECTION 23 38 13**  
**COMMERCIAL-KITCHEN HOODS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Cooking hoods.
- B. Condensate (dishwashing) hoods.

**1.02 RELATED REQUIREMENTS**

- A. Section 10 44 00 - Fire Protection Specialties: Hand held fire extinguishers.
- B. Section 11 40 00 - Foodservice Equipment: General provisions for hoods.
- C. Section 28 31 00 - Fire Detection and Alarm: Connection of hood fire extinguishing system and fire dampers to building fire alarm system.
- D. Section 21 13 00 - Fire-Suppression Sprinkler Systems: Connection of hood fire extinguishing system to sprinkler system.
- E. Section 22 10 06 - Plumbing Piping Specialties: Floor drains for indirect discharge.
- F. Section 22 10 06 - Plumbing Piping Specialties: Electrically-operated gas valve for cooking equipment.
- G. Section 23 31 00 - HVAC Ducts and Casings: Exhaust and make-up air ducts.

**1.03 REFERENCE STANDARDS**

- A. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
- B. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- C. SMACNA (KVS) - Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines.
- D. UL 710 - Standard for Exhaust Hoods for Commercial Cooking Equipment.

**1.04 SUBMITTALS**

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
  - 1. Preparation instructions and recommendations.
  - 2. Storage and handling requirements and recommendations.
  - 3. Installation instructions, adjusting and balancing methods.

**PART 2 PRODUCTS**

**2.01 HOOD CONSTRUCTION**

- A. Provide products that comply with NFPA 96, the requirements and recommendations of SMACNA Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines, and the requirements of the authorities having jurisdiction.
- B. Cooking Hoods: Provide Type I hoods, with all external joints and seams continuously welded, liquid-tight, and all internal joints, seams, and attachments sealed liquid-tight and grease-tight.
  - 1. Provide fire extinguishing system for all cooking hoods.
  - 2. Provide complete assemblies listed and labeled by UL under UL 710 for its intended use.
  - 3. Provide hoods and exhaust ducts rated for zero clearance to combustible construction.
- C. Condensate Hoods: Provide Type II hoods with all joints and seams liquid-tight.
  - 1. Inside the bottom perimeter provide an integral formed condensate gutter:

2. Gutter Dimensions: 3 inches wide with one inch flange turned up at 45 degree angle.
  3. Drain: Stainless steel, one inch diameter, located in back corner of gutter.
  4. Pipe drain to nearest sink drainboard or floor drain.
- D. Construction: All materials, inside and out, stainless steel complying with ASTM A666, Type 304, stretcher leveled; unless otherwise indicated.
1. Sheet Thickness: 18 gage, 0.048 inch, minimum.
  2. Fabrication: Fabricate each individual hood in one piece, with all welds ground and finished to match (inside and out); fabricate flat surfaces exposed to view as double-pan formed panels with internal stiffener members.
  3. Finish on Surfaces Exposed to View: No.4 (brushed directional); provide stainless steel faces on all sides exposed to view.
  4. Finish on Concealed Surfaces: No.4 or No.2B (dull, matte).
  5. Duct Collars: For exhaust and make-up air openings, provide duct collar welded to hood unit; minimum of 8 inches extension from top or back face of unit, with minimum one inch 90 degree flange, unless otherwise indicated.
  6. Access Panels: Provide removable or hinged access panels sufficient for maintenance and replacement of operating components inside unit; maximum width of 40 inches.
  7. Supports: Stainless steel mounting brackets, struts, and threaded hanger rods.
    - a. Hanger Rods: 3/8 inch diameter, minimum.
    - b. Hanger Spacing: 48 inches on center, maximum.
    - c. Attachment to Structure: Mechanical fittings or inserts, stainless steel.
- E. Make-Up Air System: Provide volume damper at inlet, accessible for balancing.
1. Diffusers: Louvered register with opposed blade dampers.
  2. Plenum: Insulated with one inch thick foil-face fiberglass insulation, on inside of plenum.
  3. Provide shunt-trip breakers for interlock with Fire Alarm system.

## 2.02 HOOD ACCESSORIES

- A. Fire Extinguishing System: Comply with NFPA 96.
1. Exposed Piping Under Hood: Stainless steel or chrome plated.
  2. Exposed Piping Outside Hood: Not permitted.
  3. Nozzles: Stainless steel or chrome plated brass.
  4. Electrical Components: Provide all components required for properly operating system, including but not limited to wiring, raceways, contactors, circuit breakers, switches and solenoids.
  5. Manual Actuators: Wall-mounted pull stations; provide one near each hood and one near exit door.
- B. Controls:
1. Fans: Provide manual push button controls for starting and stopping fans and labeled indicator lights showing fan status.
  2. Fans: Provide controls for fan operation by time clock, programmable by the week, capable of maintaining time cycle after operation of manual push buttons.
  3. Cooking Equipment: Provide manual shutoff and reset button located where indicated; combine with fire extinguishing actuation.
  4. Fire Extinguishing System: Provide automatic actuation complying with NFPA 96; provide local and remote manual actuating stations clearly labeled "Hood Fire Protection"; upon actuation of fire extinguishing system, automatically:
    - a. Shut off fans serving that hood.
    - b. Shut off fuel source to equipment under hood; actuate solenoid gas valves provided as part of gas piping work.
    - c. Shut off electric power to equipment under hood; actuate contactors or switches provided as part of electrical work.

- d. Signal building fire alarm system; normally-open contacts.
- C. Control Panels: Factory assembled and pre-wired, ready for utility connections.
  - 1. UL listed for use with specific hood.
  - 2. Provide a single control panel combining all control functions for a particular hood, unless otherwise indicated.
  - 3. Provide a single control panel for each group of hoods served by a single exhaust fan.
  - 4. Enclosures: Flush-mounted; stainless steel, to match hood.
  - 5. Provide indicator lights on control panel door showing status of fans and power supply.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that overhead supports are installed in correct locations.
- B. Do not begin installation until substrates have been properly prepared.
- C. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

#### **3.02 PREPARATION**

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

#### **3.03 INSTALLATION**

- A. Install in accordance with manufacturer's instructions and NFPA 96.
- B. Install hoods level and plumb, securely fastened, with seismic restraints as specified, and free of vibration during normal operation.
- C. Weld hood duct collars to ductwork, liquid-tight.
- D. Connect to utilities.

#### **3.04 SYSTEM STARTUP**

- A. Obtain the services of the manufacturer's representative experienced in the installation, adjustment, and operation of the equipment to supervise the starting and adjusting of equipment.
- B. Prepare equipment for startup, start and operate equipment for sufficient period to verify proper operation; correct equipment not operating correctly.
- C. Test liquid carrying components for leaks.
- D. Adjust volume dampers as required for proper air flow after building air handling systems have been balanced and adjusted.
- E. Demonstrate operation to Owner's designated personnel.
- F. Demonstrate operation to authorities having jurisdiction if required by them; comply with their requirements for demonstration.
- G. Report deficiencies in writing to Architect.

#### **3.05 CLOSEOUT ACTIVITIES**

- A. Conduct training of Owner's designated personnel in the operation and maintenance of equipment.
- B. Perform at least 2 hours of training, for minimum of 2 people, at project site.
- C. Arrange training sessions with Owner at least 2 weeks in advance.
- D. Have operation and maintenance data on hand for training sessions.

**3.06 CLEANING**

- A. Clean surfaces of equipment.

**3.07 PROTECTION**

- A. Protect installed products until completion of project.
- B. Touch-up, repair or replace damaged products before Substantial Completion.

**END OF SECTION**



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

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Packaged dessicant air-to-air energy recovery units.
- B. Duct-Mounted Pre-Heat Coils

**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
- E.

**1.03 REFERENCE STANDARDS**

- A. AHRI 1060 I-P - Performance Rating of Air-to-Air 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 E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- E. NFPA 70 - National Electrical Code.
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- G. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials
- H. 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.

**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 motor to be free from defects in material and workmanship for 7 years under circumstances of normal use.

- C. Warranty dessicant core to be free from defects in material and workmanship for 10 years under circumstances of normal use.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Energy Recovery Ventilators:
  - 1. Renew Aire: [www.renewaire.com](http://www.renewaire.com).
  - 2. Nu-Air: [www.nu-air.com](http://www.nu-air.com)
  - 3. Innovent: [www.innoventair.com](http://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. Framing: Welded extruded aluminum tubular frame capable of supporting components and casings.
  - 4. Permanent name plate listing manufacturer mounted inside door near electrical panel.

### **2.03 CASING**

- A. Wall, Floor, and Roof Panels:
  - 1. Construction: 2 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. 22 gage, 0.0299 inch galvanized sheet metal.
  - 4. Insulation:
    - a. 2 inch insulated fiberglass board insulation.
    - b. All insulation sealed with foil/scrim facing leaving no exposed insulation to the airstream.
    - c. Flame Spread Index: 25, maximum, when tested in accordance with ASTM E84, NFPA 255, and UL 723.
    - d. 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. Factory finished in a custom color as selected by the architect.
- 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. Corrosion-resistant.

**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 non-sparking integral spun steel venturie inlet cones.
- 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, 0.1046 inch aluminized steel with plenums integral to general housing and constructed to Class 1 fan standards.
- E. Motors:
  - 1. Motors: ECM direct drive or VFD-driven as scheduled.
  - 2. Efficiency: Premium.
  - 3. Speed: Variable.
  - 4. Control: Variable Frequency Drive.
  - 5. Motor Slide Bases: Removable and adjustable.
  - 6. Fan Motor: Thermal overload protected.
  - 7. 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. Effectiveness: Rated in accordance with ASHRAE Std 84 and AHRI 1060.
- C. Flame Spread Index: 25, maximum, when tested in accordance with ASTM E84, NFPA 255, and UL 723.
- D. Smoke Developed Index: 50, maximum, when tested in accordance with ASTM E84, NFPA 255, and UL 723.
- E. Energy Recovery Media Facing:
  - 1. Conform to NFPA 90A.
- F. Coat all corrugated surfaces with a thin non-migrating absorbent layer.

**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. Filter Racks: Bolt-on rack constructed of 0.08 inch, minimum, thick aluminum with hinged side access door and snap fasteners.

- E. Filter Removal Hooks: Provide means to remove filters that are not immediately accessible from exterior of unit
- F. Mount 1/2 inches thick permanent aluminum washable type filter in the outside air hood and in the return plenum air.

## **2.07 DAMPERS**

- A. Motorized Dampers: Provide motorized dampers at outside air inlet, exhaust air outlet, and supply air outlet.
  - 1. Type: Motorized two position low-leak.
  - 2. Blades: Insulated, single blade damper.

## **2.08 VIBRATION ISOLATION**

- A. Vibration Isolation: Provide enclosed spring isolators having minimum 2" static deflection.
- B. Construct with appropriately-sized, seismic-rated, corrosion-resistant captive-spring isolators.

## **2.09 ROOF CURBS**

- A. Curbs: Provide full perimeter vibration-isolating roof curb fabricated from 10 gage aluminized steel.
  - 1. Curbs: Knock-down type.
  - 2. Provide slope for roof deck as required.
- B. 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.

## **2.10 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.

## **2.11 ACCESSORIES**

- A. Electric Preheat Coil (Duct Mounted):
  - 1. Resistance coil type with elements enclosed in a steel sheath with fins and painted with a baked-on aluminum paint for long life in a 100% fresh air stream.
  - 2. Coil: UL listed and constructed in accordance with NFPA 70 requirements.
  - 3. Controls: Factory-provided SCR controls to maintain defined temperature (see schedule for details).

## **2.12 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. 60 Hz power connection.

2. Isolate electrical box from the airflow.
3. Protect all integral wires and connections.
4. Electrical Components: UL Listed.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

#### **3.02 INSTALLATION**

- A. Provide openings for suitable ductwork connection.

#### **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**

**SECTION 23 74 13****PACKAGED OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Packaged roof top unit.
- B. Unit controls.
- C. Remote panel.
- D. Mounting curb and base.
- E. Maintenance service.

**1.02 RELATED REQUIREMENTS**

- A. Section 07 62 00 - Sheet Metal Flashing and Trim.
- B. Section 23 05 13 - Common motor requirements for HVAC Equipment.
- C. Section 23 05 48 - Vibration and Seismic Con. for Equipment.
- D. Section 23 40 00 - HVAC Air Cleaning Devices.
- E. Section 23 09 13 - Instrumentation and Control Devices for HVAC: Control components, time clocks.
- F. Section 23 09 13 - Instrumentation and Control Devices for HVAC: Installation of thermostats and other controls components.
- G. Section 26 27 17 - Equipment Wiring: Installation and wiring of thermostats and other controls components; wiring from unit terminal strip to remote panel.
- H. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

**1.03 REFERENCE STANDARDS**

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- B. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment.
- C. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

**1.04 SUBMITTALS**

- A. See Section 01 33 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
- C. Shop Drawings: Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
- D. Manufacturer's Instructions: Indicate assembly, support details, connection requirements, and include start-up instructions.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- F. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner'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 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.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Protect units from physical damage by storing off site until roof mounting curbs are in place, ready for immediate installation of units.

**1.07 WARRANTY**

- A. Provide a five year warranty to include coverage for refrigeration compressors and heat exchangers.

**1.08 MAINTENANCE SERVICE**

- A. Furnish service and maintenance of packaged roof top units for one year from Date of Substantial Completion.
- B. Provide maintenance service with a two month interval as maximum time period between calls. Provide 24-hour emergency service on breakdowns and malfunctions.
- C. Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of six filter replacements, minimum of one fan belt replacement, and controls check-out, adjustments, and recalibration.
- D. Submit copy of service call work order or report, and include description of work performed.

**1.09 EXTRA MATERIALS**

- A. Provide two sets of filters.

**PART 2 PRODUCTS****2.01 MANUFACTURERS**

- A. Munters
- B. Innovent
- C. Trane Horizon

**2.02 AIR CONDITIONING UNITS**

- A. General: Roof mounted packaged units having gas burner as scheduled and electric refrigeration.
- B. Description: Self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, return fan, heat exchanger and burner, , energy recovery wheel (where noted in the schedule), factory-mounted controls, air filters, gas heating coil, refrigerant cooling coil, variable-capacity compressors and hot-gas reheat circuits, condenser coil and condenser fan as scheduled.
- C. Disconnect Switch: Factory mount disconnect switch on equipment under provisions of Section 26 27 17.

**2.03 FABRICATION**

- A. Cabinet: Galvanized steel with baked enamel finish, factory finished in custom color as selected by the architect including access doors with piano hinges and locking handle. Structural members shall be minimum 18 gage, with access doors or panels of minimum 20 gage.
- B. Insulation: two inch thick minimum glass fiber or injected foam, double-walled unit construction.
- C. Heat Exchangers: Stainless steel, of welded construction.

- D. Supply and Return and Exhaust Fan as scheduled: Backward inclined or airfoil type, resiliently mounted with V-belt drive and adjustable variable pitch motor pulley, and rubber isolated hinge mounted high efficiency motor or direct drive as indicated. Isolate complete fan assembly. Provide factory-mounted variable-frequency drives for all fan motors.
- E. Air Filters: Minimum efficiency reporting value (MERV) of at least 13 on OA and RA air streams.
- F. Vibration Isolation: Units are to be mounted on steel dunnage. Provide enclosed spring isolators having minimum 2" static deflection.
- G. Provide 120V convenience receptacle and vapor-tight LED light fixtures in fan sections. Outlet and lights are to receive power directly from unit-mounted transformer.
- H. Provide unit as side-discharge arrangement. Downflow units with side discharge curbs are not acceptable.

#### **2.04 BURNER**

- A. Gas Burner: Forced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shut-off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut-off pilot. Provide turndown ratio as indicated in the schedule.
- B. Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after air flow proven and slight delay, allow gas valve to open.
- C. High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.
- D. Supply Fan Control: Temperature sensor sensing bonnet temperatures and independent of burner controls, with provisions for continuous fan operation.

#### **2.05 EVAPORATOR COILS**

- A. Provide copper tube aluminum fin coil assembly with stainless steel drain pan and connection for cooling coils.
- B. Provide thermostatic expansion valves for units of 6 tons capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons cooling capacity and larger.

#### **2.06 COMPRESSOR**

- A. Provide hermetic compressors, 3600 rpm maximum, resiliently mounted with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gage ports, and filter drier.
- B. Five minute timed off circuit to delay compressor start.
- C. Outdoor thermostat to energize compressor above 35 degrees F ambient.
- D. Provide modulating capacity control by variable-capacity scroll technology and/or adjusting variable-speed compressors.
- E. Provide hot-gas reheat coil for humidity control.

#### **2.07 CONDENSER OR OUTDOOR COIL**

- A. Provide copper tube aluminum or copper fin coil assembly with subcooling rows and coil guard.
- B. Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor. Provide high efficiency fan motors.
- C. Provide refrigerant pressure switches to cycle condenser fans.
- D. Provide variable frequency drives on all condenser fans for active head pressure control.



**2.08 MIXED AIR CASING**

- A. Dampers: Provide outside, return, and relief dampers with damper operator and control package to automatically vary outside air quantity. Outside air damper to fall to closed position.
- B. Gaskets: Provide tight fitting dampers with edge gaskets.
- C. Damper Operator, Units 7.5 Ton Cooling Capacity and Larger: 24 volt with gear train sealed in oil with spring return on.
- D. Outdoor airflow monitoring station: Provided at intake of the unit.
- E. Mixed Air Controls: Maintain selected supply air temperature and return dampers to minimum position on call for heating and above 70 degrees (F) ambient, or when ambient air enthalpy exceeds return air enthalpy.

**2.09 OPERATING CONTROLS**

- A. Provide factory controller and all necessary sensors and components for operation of refrigerant system, fan VFDs based on single-zone VFD control, energy recovery wheel, humidity control function, and economizer function. The humidity control (dehumidification sequence) shall be capable of being enabled when the unit is in both heating and cooling modes. The humidistat setpoint shall govern control of this sequence.
- B. Provide BACnet interface on unit for connection of operating controls for BAS control. Control shall allow for modulating heating via the gas-fired burner and modulating stages cooling, fan, and damper control. See section 23 09 93 for required data to be relayed to the BAS for monitoring and control.
- C. Provide remote mounted fan control switch for smoke-purge for each unit (on-auto) to activate only the exhaust fan at each unit, keep the outdoor air damper closed, and de-energize the energy wheel.
- D. See Specification Section 230993 - Sequence Of Operations, for required operating capabilities of the units.

**2.10 HEAT RECOVERY**

- A. The heat recovery module shall be provided as shown on the drawing and shall have a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seats and bearings.
- B. The energy recovery cassette shall be rated in accordance with ARI Standard 1060 and shall bear the ARI certification symbol.
- C. The energy recovery cassette shall contain a total energy heat wheel constructed of a light weight polymer material with permanently bonded desiccant coating. The energy recovery wheel media shall be capable of removal from the cassette and be cleanable using hot water or light detergent without degrading the latent efficiency.
- D. Provide variable frequency drive on energy recovery wheel.
- E. Provide bypass dampers for economizer function.

**PART 3 EXECUTION****3.01 EXAMINATION**

- A. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings or illustrated by the manufacturer.
- B. Verify that proper power supply is available.

**3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.

- B. Install in accordance with NFPA 90A.
- C. Mount units on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.
- D. Locate remote panels where identified in field coordination meeting.
- E. Tie unit into BAS as specified.
- F. All units are to be painted. Color to be selected by architect.

**3.03 SYSTEM STARTUP**

- A. Prepare and start equipment. Adjust for proper operation.

**3.04 CLOSEOUT ACTIVITIES**

- A. Demonstrate operation to Owner's maintenance personnel.

**3.05 MAINTENANCE**

- A. Provide service and maintenance of packaged roof top units for 2 years year from Date of Substantial Completion.
- B. Provide routine maintenance service with a three month interval as maximum time period between calls.
- C. Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of six filter replacements, minimum of one fan belt replacement, and controls check-out, adjustments, and recalibration.
- D. After each service call, submit copy of service call work order or report that includes description of work performed.

**END OF SECTION**

**SECTION 23 81 01**  
**TERMINAL HEAT TRANSFER UNITS**

**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Baseboard radiation.
- B. Unit heaters.
- C. Cabinet unit 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 Owner'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 two year parts and labor warranty for entire unit, from substitute and completion.

**PART 2 PRODUCTS****2.01 GAS UNIT HEATERS**

- A. Manufacturers:

1. Trane Inc: [www.trane.com/#sle](http://www.trane.com/#sle).
  2. Rittling [www.rittling.com](http://www.rittling.com) .
  3. Modine.
  4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Heat Exchanger: Stainless Steel.
- C. Casing: 0.0478 inch steel with threaded pipe connections for hanger rods.
- D. Finish: Factory applied baked enamel of color as selected.
- E. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.
- F. Air Outlet: Adjustable pattern diffuser on projection models and two or four way louvers as scheduled on horizontal throw models.
- G. Motor: ECM Motor.
- H. Control: Local multi-speed or via BAS, disconnect switch. See Sequence of Operations for ATC requirements.
- I. Capacity: As scheduled.

## **2.02 ELECTRIC BASEBOARD**

- A. Manufacturers:
1. QMark.
  2. Marley.
  3. Trane.
  4. 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, baseboard mounted electronic thermostat.

## **2.03 ELECTRIC UNIT HEATERS AND ELECTRIC CABINET UNIT HEATERS**

- A. Manufacturers:
1. QMark.
  2. Marley.
  3. Trane.
  4. Berko.
  5. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Assembly: UL listed and labelled assembly with terminal box and cover, and built-in controls. See sequence of operations for additional ATC requirements.
- 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 thermostat heat selector switch, factory wired, with switches built-in behind cover. Provide thermal overload.

### **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. Cabinet Unit Heaters: Install as indicated. Coordinate to assure correct recess size for recessed units.
- G. 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**

**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 the Performance of Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant.
- 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 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 Owner'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 coil.
  - 2. Cooling: Outdoor electric condensing unit with evaporator coil in central ducted indoor unit or coils in multiple .
  - 3. 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 DUCTED SYSTEMS**

- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.
  - 1. Air Flow Configuration: Counterflow, with additional steel base; counterflow or horizontal as scheduled.
  - 2. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
- B. Supply Fan: Centrifugal type rubber mounted with direct or belt drive with adjustable variable pitch motor pulley.
  - 1. Motor: NEMA MG 1; 1750 rpm single speed or multiple speed as scheduled permanently lubricated, hinge mounted.
  - 2. Motor Electrical Characteristics:
- C. Air Filters: 1 inch thick glass fiber, disposable type arranged for easy replacement.
- D. 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 207.
  - 2. Manufacturers: System manufacturer.

**2.04 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 207.
  - 2. Manufacturer: System manufacturer.

**2.05 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 23.1 and UL 207.
- 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.

## **2.06 ACCESSORY EQUIPMENT**

- A. Room Humidistat: Electric, adjustable, to energize humidifier when fan operating, to maintain setting.
- B. Room Thermostat: Wall-mounted, electric solid state microcomputer based room thermostat with remote sensor to maintain temperature setting; low-voltage; with following features:
  1. System selector switch (heat-off-cool) and fan control switch (auto-on).
  2. Automatic switching from heating to cooling.
  3. Preferential rate control to minimize overshoot and deviation from setpoint.
  4. Set-up for four separate temperatures per day.
  5. Instant override of setpoint for continuous or timed period from one hour to 31 days.
  6. Short cycle protection.
  7. Programming based on every day of the week.
  8. Selection features including degree F or degree C display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on-auto.
  9. Battery replacement without program loss.
  10. Thermostat display:
    - a. Time of day.
    - b. Actual room temperature.
    - c. Programmed temperature.
    - d. Programmed time.
    - e. Duration of timed override.
    - f. Day of week.
    - g. System mode indication: heating, cooling, fan auto, off, and on, auto or on, off.
  11. Manufacturers:
    - a. Matching unit manufacturer or provided by Building Automation System vendor..

## **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. Install in accordance with NFPA 90A and NFPA 90B.
- C. Provide vent connections in accordance with NFPA 211.
- D. Install refrigeration systems in accordance with ASHRAE Std 15.
- E. Mount counterflow furnaces installed on combustible floors on additive base.

**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 I-P - 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. Control Panels: Complete description of options, control points, zones/groups.
- E. Specimen Warranty: Copy of manufacturer's warranties.
- F. 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.
- G. 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.
- H. 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.
- I. 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 EXTRA MATERIALS**

- A. Provide 2-piece filter assemblies for indoor ducted units.
- B. Provide two (2) spare filter sets for each indoor unit.

#### **1.09 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 preformed 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 Samsung.
- B. Additional acceptable manufacturers:
  - 1. Daikin.
  - 2. Mitsubishi.
  - 3. Samsung.
  - 4. LG.
- C. For systems proposed by other manufacturers other than the basis of design, Samsung, all 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.
    - a. **UNDER NO CIRCUMSTANCES MAY BLOWER COIL OR FAN COIL TERMINAL UNITS BE GROUPED TOGETHER ON THE SAME ELECTRICAL CIRCUIT. All units must maintain a dedicated circuit to each.**
  - 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 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 maintainence 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. Cooling Mode Interior Design Performance:
  - 1. Daytime Setpoint: 75 degrees F, plus or minus 2 degrees F.
  - 2. Setpoint Range: 57 degrees F to 80 degrees F.
  - 3. Night Setback: 78 degrees F.
  - 4. Interior Relative Humidity: 50 percent, maximum.
- C. Heating Mode Interior Design Performance:
  - 1. Daytime Setpoint: 70 degrees F, plus or minus 2 degrees F.

2. Setpoint Range: 59 degrees F to 76 degrees F.
  3. Night Setback: 60 degrees F.
  4. Interior Relative Humidity: 20 percent, minimum.
- D. Outside Air Design Conditions:
1. Summer Outside Air Design Temperature: 0.4 percent cooling design condition listed in ASHRAE Fundamentals Handbook.
- E. 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.
- F. Controls: Provide the following control interfaces:
1. For Each Indoor/Evaporator Unit: One wall-mounted wired "local" controller, with temperature sensor; locate where directed, in each space.
    - 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.
  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 indicated.
- G. Local Controllers: Mount units above ceiling for use with remote, flat-plate temperature sensors. Units shall be wired, and provide local setpoint adjustment (with central control override, maximum temperature adjustment), and temperature display for trouble-shooting.
- H. Remote Temperature Sensors: Provide wall-mounted, flush-mount flat-plate style RTD temperature sensors located in the same room for all units. For rooms with multiple units, provide twinning kits for simultaneous control.

## 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](http://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:
  7. 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 its 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 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. 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.
  2. 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.
  3. Provide each compressor with crankcase heater, high pressure safety switch, and internal thermal overload protector.
  4. Provide oil separators and intelligent oil management system.
  5. 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. 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.
  2. When branch unit is simultaneously heating and cooling, energize subcooling heat exchanger.
  3. Casing: Galvanized steel sheet; with flame and heat resistant foamed polyethylene sound and thermal insulation.
  4. Refrigerant Connections: Braze type.
  5. 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
  7. Condensate Drainage: Built-in condensate drain pan with PVC drain connection.
  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 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 21 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 9 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 Drain Connection: Side (end), not concealed in wall.
  4. 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. Verify that condensate piping has been installed and is in the proper location prior to starting installation.
- C. Notify Architect 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 Owner's designated representative.
- B. Demonstration: Demonstrate operation of system to Owner'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 Owner'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**