

PROJECT MANUAL FOR

# AL/MC – HARBORCHASE OF FARMINGTON HILLS

Farmington Hills, Michigan

# <u>Permit Set</u>

# **VOLUME 2**

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(Division 21 through 33)

October 24, 2019



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# TABLE OF CONTENTS

Refer to the Construction Manager's Project Manual issued by The Douglas Company for additional procurement, contracting, and general requirements.

# **VOLUME 2**

# **DIVISION 21 - FIRE SUPPRESSION**

- 21 0500 Common Work Results for Fire Suppression
- 21 1000 Water Based Fire Suppression Systems

# **DIVISION 22 - PLUMBING**

- 22 0500 Common Work Results for Plumbing
- 22 0513 Common Motor Requirements for Plumbing Equipment
- 22 0519 Meters and Gages for Plumbing Piping
- 22 0523 General Duty Valves for Plumbing Piping
- 22 0529 Hangers and Supports for Plumbing Piping and Equipment
- 22 0553 Identification for Plumbing Piping and Equipment
- 22 0700 Plumbing Insulation
- 22 0800 Commissioning Of Plumbing
- 22 1116 Domestic Water Piping
- 22 1119 Domestic Water Piping Specialties
- 22 1123 Domestic Water Pumps
- 22 1316 Sanitary Waste and Vent Piping
- 22 1319 Sanitary Waste Piping Specialties
- 22 1413 Facility Storm Drainage Piping
- 22 1423 Storm Drainage Piping Specialties
- 22 3400 Fuel Fired Domestic Water Heaters
- 22 4000 Plumbing Fixtures

# **DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)**

- 23 0500 Common Work Results for HVAC
- 23 0513 Common Motor Requirements for HVAC Equipment
- 23 0553 Identification for HVAC Piping and Equipment
- 23 0593 Testing, Adjusting, and Balancing for HVAC
- 23 0700 HVAC Insulation
- 23 0800 Commissioning of HVAC
- 23 0900 Instrumentation and Control for HVAC
- 23 1123 Facility Natural Gas Piping
- 23 2300 Refrigerant Piping
- 23 3113 Metal Ducts
- 23 3300 Air Duct Accessories
- 23 3423 HVAC Power Ventilators
- 23 3713 Diffusers, Registers, and Grilles
- 23 3723 HVAC Gravity Ventilators
- 23 7200 Air-To-Air Energy Recovery Equipment



- 23 7413 Package Outdoor, Central-Station Air-Handling Units
- 23 8126 Variable Refrigerant Flow HVAC System
- 23 8127 Split System Air Conditioners

# **DIVISION 26 - ELECTRICAL**

- 26 0500 Common Work Results for Electrical
- 26 0519 Low-Voltage Electrical Power Conductors and Cables
- 26 0529 Hangers and Supports for Electrical Systems
- 26 0533 Raceways and Boxes for Electrical Systems
- 26 0543 Underground Ducts and Raceways for Electrical Systems
- 26 0544 Sleeves and Sleeve Seals for Electrical Raceways and Cabling
- 26 0553 Identification for Electrical Systems
- 26 0573.13 Short Circuit Studies
- 26 0573.16 Coordination Studies
- 26 0574 Overcurrent Protective Device Arc-Flash Study
- 26 0913 Electrical Energy Metering
- 26 0923 Lighting Control Devices
- 26 0943.23 Lighting Control System
- 26 2200 Low Voltage Transformers
- 26 2300 Low Voltage Switchgear
- 26 2413 Switchboards
- 26 2416 Panelboards
- 26 2726 Wiring Devices
- 26 2813 Fuses
- 26 3213 Engine Generators
- 26 3600 Transfer Switches
- 26 4313 Surge Protection for Low-Voltage Electrical Power Circuits
- 26 5100 Interior Lighting
- 26 5600 Exterior Lighting

# **DIVISION 27 - COMMUNICATIONS**

- 27 0500 Common Work Results for Communications Systems
- 27 0513 Area of Rescue Assistance System
- 27 0526 Grounding and Bonding for Communications Systems
- 27 0553 Identification for Communication Systems
- 27 0560 Communications Firestopping
- 27 1100 Communications Room Provisioning
- 27 1310 Backbone Copper Cable and Equipment
- 27 1320 Fiber Optic Cable and Equipment
- 27 1510 Horizontal Copper Cable and Equipment
- 27 5113 Overhead Speaker-Sound System
- 27 5223 Wireless Emergency Call

# **DIVISION 28 - ELECTRONIC SAFETY AND SECURITY**

- 28 1300 Access Control
- 28 2300 Video Surveillance
- 28 3100 Fire Detection and Alarm

# **DIVISION 31 - EARTHWORK**

- 31 1000 Site Clearing
- 31 2000 Earth Moving
- 31 2319 Dewatering

# **DIVISION 32 - EXTERIOR IMPROVEMENTS**

- 32 1216 Asphalt Paving
- 32 1313 Concrete Paving
- 32 1373 Concrete Paving Joint Sealants
- 32 1723 Pavement Markings
- 32 1726 Tactile Warning Surfacing

# **DIVISION 33 - UTILITIES**

- 33 1000 Water Distribution
- 33 3000 Sanitary Sewers
- 33 4100 Storm Drainage

# END OF TABLE OF CONTENTS

# SECTION 21 0500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

# PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Piping materials and installation instructions common to most piping systems.
  - 2. Sleeve-seal systems.
  - 3. Sleeves.
  - 4. Stack-sleeve fittings.
  - 5. Escutcheons.
  - 6. Grout.
  - 7. Fire-suppression equipment and piping demolition.
  - 8. Equipment installation requirements common to equipment sections.
  - 9. Painting and finishing.
  - 10. Supports and anchorages.

#### 1.2 QUALITY ASSURANCE

- A. Provide fire-suppression systems, equipment, and materials in accordance with NFPA and other applicable codes and regulations, and with authorities having jurisdiction.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
  - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
  - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- D. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

# 1.3 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to

prevent damage during shipment, storage, handling, and up to substantial completion. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion.

# 1.4 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.
- B. Coordinate installation of required supporting devices and sleeves with structural components.
- C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

# PART 2 - PRODUCTS

- 2.1 PIPE, TUBE, AND FITTINGS
  - A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.
  - B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.
  - C. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
    - 1. All castings used for coupling housings, fittings, valve bodies, etc., shall include listing/approval stamp, label, or other markings made to specified standards.

#### 2.2 JOINING MATERIALS

- A. Refer to individual Division 21 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
  - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch(3.2-mm) maximum thickness unless thickness or specific material is indicated.
    - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

# 2.3 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
  - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 2. Pressure Plates: Plastic.
  - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

# 2.4 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

# 2.5 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
  - 1. Underdeck Clamp: Clamping ring with setscrews.

# 2.6 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.
- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- E. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.

F. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed or exposed-rivet hinge, and spring-clip fasteners.

# 2.7 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

# PART 3 - EXECUTION

# 3.1 FIRE-SUPPRESSION DEMOLITION

- A. Refer to Division 01 Section "Execution" and Division 02 Section "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove fire-suppression systems, equipment, and components indicated to be removed.
  - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material within 6 inches on main.
  - 2. Equipment to Be Removed: Disconnect and cap services and remove equipment.
  - 3. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
  - 4. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

# 3.2 PIPING SYSTEMS - COMMON INSTALLATION REQUIREMENTS

- A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved.
  - 1. Drawings are diagrammatic with no attempt made to show every ell, tee, transition, fitting, or appurtenance. Provide installations that are complete in every detail, compliant with all applicable codes, and as required to provide a fully functional and operational system even though every item is not specifically indicated.

- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Select system components with pressure rating equal to or greater than system operating pressure.

# 3.3 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and finished floors according to the following:
  - 1. Escutcheons for New Piping:
    - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
    - c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
    - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
    - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or splitcasting brass type with polished, chrome-plated finish.
    - f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
    - g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
  - 2. Escutcheons for Existing Piping:
    - a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
    - b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge.
    - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    - e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chromeplated or rough-brass finish.
    - f. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated or rough-brass finish.

# 3.4 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
  - 1. Sleeves are not required for core-drilled holes.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1inch (25-mm) annular clear space between piping and concrete slabs and walls.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
  - 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
  - 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
  - Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 9200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

# 3.5 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
  - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
  - Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 6200 "Sheet Metal Flashing and Trim."
  - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
  - Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
  - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

# 3.6 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

# 3.7 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
  - 1. Exterior Concrete Walls Above Grade:
    - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves, galvanized-steel wall sleeves, or galvanized-steel-pipe sleeves.
    - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves, galvanized-steel wall sleeve, or galvanized-steel-pipe sleeves.
  - 2. Exterior Concrete Walls below Grade:
    - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
    - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
  - 3. Concrete Slabs-on-Grade:
    - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
    - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
  - 4. Concrete Slabs above Grade:
    - a. Piping Smaller Than NPS 6 (DN 150): Stack-sleeve fittings.
    - b. Piping NPS 6 (DN 150) and Larger: Stack-sleeve fittings.

- 5. Interior Partitions:
  - a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves.
  - b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-sheet sleeves.

# 3.8 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- E. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

# 3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Sequence, coordinate, and integrate installations of fire suppression equipment, giving particular attention to large equipment requiring positioning prior to closing in the building.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
- E. Install equipment to allow right of way for piping installed at required slope.
- F. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
- G. Verify final equipment locations for roughing-in.

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

#### 3.10 PAINTING

- A. Painting of fire-suppression systems, equipment, and components is specified in Division 09 painting sections.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

# 3.11 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

#### 3.12 GROUTING

- A. Mix and install grout for fire protection installations.
  - 1. Clean surfaces that will come into contact with grout.
  - 2. Provide forms as required for placement of grout.
  - 3. Avoid air entrapment during placement of grout.
  - 4. Cure placed grout.

# 3.13 INSTALLATION OF ACCESS DOORS

- A. Where lay-in ceilings are used, the access to ceiling space is provided through the removable ceiling panels. Where access is required to valves, pipes, dampers or other devices in spaces above non-removable ceilings or in chases, the Contractor requiring the access doors shall provide access doors. Access doors required in rated walls and ceiling shall bear the same rating. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
  - 1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
  - 2. Adjust hardware and panels after installation for proper operation.

# 3.14 FIELD QUALITY CONTROL

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

# END OF SECTION 21 0500

# SECTION 21 1000 – WATER BASED FIRE SUPPRESSION SYSTEMS

# PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following fire-suppression piping inside the building:
  - 1. Wet-pipe sprinkler systems.
  - 2. Double preaction sprinkler systems.
- B. This Section also includes modifying the existing fire-suppression sprinkler system for remodeled portion of the building.
- C. Related Sections include the following:
  - 1. Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.

# 1.2 SYSTEM DESCRIPTIONS

- A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.
- B. Double-Interlock Preaction Sprinkler System: Automatic sprinklers are attached to piping containing lowpressure air. Actuation of a fire-detection system, located in same area as sprinklers, opens deluge valve, permitting water to flow into sprinkler piping. A closed solenoid valve in the sprinkler piping is opened by another fire-detection device; water will then discharge from opened sprinklers.

# 1.3 PERFORMANCE REQUIREMENTS

- A. Standard Piping System Component Working Pressure: Listed for at least 175 psig(1200 kPa).
- B. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction.
  - 1. Maximum Protection Area per Sprinkler: Per UL listing, NFPA, and manufacturers specifications.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
  - 1. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
  - 2. Air compressors, including electrical data.
  - 3. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.

- 4. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
- 5. Alarm devices, including electrical and wiring data.
- B. Fire-hydrant flow test report.
- C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations, if applicable.

# 1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- B. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13.
- 1.6 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

# 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Sprinkler Cabinets: Finished, wall-mounting, steel cabinet with hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench.

# 1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Installation and alterations of fire protection piping, equipment, specialties, and accessories, and repair and servicing of equipment shall be performed only by a qualified installer experienced in such work; with a minimum of 5 previous projects similar in size and scope to this project; be familiar with all precautions required; and has complied with all the requirements of the authority having jurisdiction.
  - 1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
    - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer or NICET Level III or IV certified layout technician.
- B. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with NFPA requirements.

# 1.9 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- PART 2 PRODUCTS
- 2.1 STEEL PIPE AND FITTINGS
  - A. Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795.
    - 1. Main and line piping NPS 2 (DN 50) and larger to be Schedule 10 grooved.
    - 2. Line piping NPS 1-1/2 (DN 40) and smaller to be Schedule 40 threaded.
      - a. If hydraulically proven, NPS 1-1/4 (DN 30) and NPS 1-1/2 (DN 40) may be Schedule 10.
  - B. Steel Pipe Fittings:
    - 1. Cast-Iron Threaded Flanges: ASME B16.1.
    - 2. Malleable-Iron Threaded Fittings: ASME B16.3.
    - 3. Gray-Iron Threaded Fittings: ASME B16.4.
    - 4. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe. Include ends matching joining method.
    - 5. Steel Threaded Couplings: ASTM A 865.
    - 6. Locking-Lug Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn to secure pipe in fitting.
    - 7. Steel Welding Fittings: ASTM A 234/A 234M, and ASME B16.9 or ASME B16.11.
    - 8. Steel Flanges and Flanged Fittings: ASME B16.5.
  - C. Grooved-Joint Piping Systems:
    - 1. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
    - 2. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, rubber gasket listed for use with housing, and steel bolts and nuts.
    - 3. Gaskets: Material, thickness, and type suitable for intended service and design system temperatures and pressures.

# 2.2 SPRINKLER SPECIALTY FITTINGS

- A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig(1200-kPa) minimum workingpressure rating, and made of materials compatible with piping.
- B. Outlet Specialty Fittings:
  - 1. Mechanical-T and -Cross Fittings: UL 213, ductile-iron housing with gaskets, bolts and nuts, and threaded, locking-lug, or grooved outlets.

- 2. Snap-On and Strapless Outlet Fittings: UL 213, ductile-iron housing or casting with gasket and threaded outlet.
- C. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.
- D. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.
- E. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.
- F. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.

# 2.3 LISTED FIRE-PROTECTION VALVES

- A. Valves shall be UL listed or FMG approved, with 175-psig(1200 kPa) minimum pressure rating.
- B. Ball Valves: Comply with UL 1091, except with ball instead of disc.
  - 1. NPS 1-1/2(DN 40) and Smaller: Bronze body with threaded ends.
  - NPS 2 and NPS 2-1/2(DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
  - 3. NPS 3(DN 80): Ductile-iron body with grooved ends.
- C. Butterfly Valves: UL 1091.
  - 1. NPS 2(DN 50) and Smaller: Bronze body with threaded ends.
  - 2. NPS 2-1/2(DN 65) and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.
- D. Check Valves NPS 2(DN 50) and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.
- E. Gate Valves: UL 262, OS&Y type.
  - 1. NPS 2(DN 50) and Smaller: Bronze body with threaded ends.
  - 2. NPS 2-1/2(DN 65) and Larger: Cast-iron body with flanged ends.
- F. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.
  - 1. Indicator: Electrical, 115-V ac, prewired, single- or dual-circuit, supervisory switch.
  - 2. NPS 2(DN 50) and Smaller: Ball or butterfly valve with bronze body and threaded ends.
  - 3. NPS 2-1/2(DN 65) and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.

# 2.4 UNLISTED GENERAL-DUTY VALVES

- A. Ball Valves NPS 2(DN 50) and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome-plated brass ball, 600-psig(4140-kPa) minimum CWP rating, blowout-proof stem, and threaded ends.
- B. Check Valves NPS 2(DN 50) and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.
- C. Gate Valves NPS 2(DN 50) and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.
- D. Globe Valves NPS 2(DN 50) and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

# 2.5 SPECIALTY VALVES

- A. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig(1200-kPa) minimum pressure rating.
  - 1. Alarm Check Valves: UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, and fill-line attachment with strainer.
  - 2. Preaction Valves: UL 260, differential type; with bronze seat with O-ring seals, single-hinge pin, and latch design. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
    - a. Air Compressor: UL 753, fractional horsepower, 120-V ac, 60 Hz, single phase.
- B. Automatic Drain Valves: UL 1726, NPS 3/4(DN 20), ball-check device with threaded ends.

# 2.6 CONTROL PANELS

- A. Description: Single-area, two-area, or single-area cross-zoned type control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire alarm bell; lamp test facility; single-pole, doublethrow auxiliary alarm contacts; and rectifier.
  - 1. Panels: UL listed and FMG approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.

#### 2.7 SPRINKLERS

- A. Sprinklers shall be UL listed or FMG approved, with 175-psig(1200-kPa) minimum pressure rating.
- B. Automatic Sprinklers: With heat-responsive element complying with the following:

- 1. UL 199, for nonresidential applications.
- 2. UL 1767, for early-suppression, fast-response applications.
- C. Sprinkler Types and Categories: Nominal 1/2-inch(12.7-mm) orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
  - 1. Provide high temperature classification in Kiln Room.
- D. Sprinkler types, features, and options as follows:
  - 1. Extended-coverage sprinklers.
  - 2. Quick-response sprinklers.
  - 3. Concealed ceiling sprinklers, including cover plate.
  - 4. Sidewall sprinklers.
  - 5. Upright sprinklers.
- E. Sprinkler Finishes: Chrome plated, bronze, coated, or painted.
- F. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
  - 1. Ceiling Mounting: Chrome-plated steel, 2 piece, with 1-inch(25-mm) vertical adjustment.
  - 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- G. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.
- H. Use of flexible drop sprinklers is acceptable upon approval of product specification.
  - 1. Braided lines required for FMG projects.

#### 2.8 FIRE DEPARTMENT CONNECTIONS

- A. Wall-Type, Fire Department Connection: UL 405, 175-psig(1200-kPa) minimum pressure rating; with corrosion-resistant-metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR & STANDPIPE."
  - 1. Type: Flush, with two inlets and square or rectangular escutcheon plate.
  - 2. Finish: Rough chrome-plated.

# 2.9 ALARM DEVICES

- A. Alarm-device types shall match piping and equipment connections.
- B. Horn Strobe Alarm:

- 1. The horn strobe shall be listed to UL 1971 and UL 464 suitable for outdoor mounting and shall be approved for fire protective service. The horn strobe shall be wired as a primary-signaling notification appliance and comply with the Americans with Disabilities Act requirements for visible signaling appliances, flashing at 1Hz over the strobe's entire operating voltage range.
- 2. The horn strobe shall mount to a standard back box with a universal mounting plate. The notification appliance circuit wiring shall terminate at the universal mounting plate.
- C. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig(1725-kPa) pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
- D. Pressure Switch: UL 753, electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.
- E. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

# 2.10 PRESSURE GAGES

- A. Description: UL 393, 3-1/2- to 4-1/2-inch-(90- to 115-mm-) diameter, dial pressure gage with range of 0 to 250 psig(0 to 1725 kPa) minimum.
  - 1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
  - 2. Air System Piping: Include caption "AIR" or "AIR/WATER" on dial face.

# PART 3 - EXECUTION

# 3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA. Use results for system design calculations.
- B. Report test results promptly and in writing.

# 3.2 PIPING APPLICATIONS, GENERAL

- A. Shop weld pipe joints where welded piping is indicated.
- B. Do not use welded joints for galvanized-steel pipe.
- C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

D. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with cast- or malleable-iron threaded fittings and threaded joint; or grooved-end fittings, pipe couplings; and grooved joints.

# 3.3 SPRINKLER SYSTEM PIPING APPLICATIONS

A. Standard-Pressure, Wet-Pipe Sprinkler System, 175-psig(1200-kPa) Maximum Working Pressure: Provide steel piping with fittings and joining method in accordance with NFPA and local authorities requirements for applications indicated.

# 3.4 VALVE APPLICATIONS

- A. Provide the following:
  - 1. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA.
    - a. Shutoff Duty: Use ball, butterfly, or gate valves.
  - 2. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA.
    - a. Shutoff Duty: Use ball, butterfly, or gate valves.
    - b. Throttling Duty: Use ball or globe valves.

#### 3.5 JOINT CONSTRUCTION

- A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping joint construction.
- B. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 (DN 200) with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage and comply with ASME B1.20.1.
- C. Twist-Locked Joints: Insert plain-end piping into locking-lug fitting and rotate retainer lug one-quarter turn.
- D. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
  - 1. Ductile-Iron Pipe: Radius-cut-groove ends of piping. Use grooved-end fittings and grooved-endpipe couplings.
  - 2. Steel Pipe: Square-cut or roll-groove piping as indicated. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.
  - 3. Pre-action Pipe Systems: Use fittings and gaskets listed for dry-pipe service.

# 3.6 WATER-SUPPLY CONNECTION

A. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories as required by authorities having jurisdiction at connection to water-service piping.

# 3.7 PIPING INSTALLATION

- A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping installation.
- B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
  - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- C. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- D. Install unions adjacent to each valve in pipes NPS 2(DN 50) and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.
- E. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2(DN 65) and larger connections.
- F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.
- G. Install sprinkler piping with drains for complete system drainage.
- H. Install sprinkler zone control valves, test assemblies, and drain risers in accessible locations.
- I. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.
- J. Install alarm devices in piping systems.
- K. Hangers and Supports: Comply with NFPA 13 for hanger materials.
- L. Install pressure gages on riser or feed main, and at each sprinkler test connection. Include pressure gages with connection not less than NPS 1/4(DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- M. Fill wet-pipe sprinkler system piping with water.
- N. Pressurize and check pre-action sprinkler system piping and air-pressure maintenance devices.

# 3.8 VALVE INSTALLATION

- A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Specialty Valves:
  - 1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.
  - 2. Preaction Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
    - a. Install air compressor and compressed-air supply piping.
    - b. Install control panel.

# 3.9 SPRINKLER APPLICATIONS

- A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types:
  - 1. Rooms without Ceilings: Upright sprinklers.
  - 2. Rooms with Suspended Ceilings: Concealed sprinklers.
  - 3. Rooms with Hard Ceilings: Concealed sprinklers.
  - 4. Wall Mounting: Sidewall sprinklers.
  - 5. Sprinkler Finishes:
    - a. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view.
    - b. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
    - c. Areas with Blacked-Out Exposed Ceilings: Painted or coated black.
    - d. Areas with White Painted Exposed Ceilings: Painted or coated white.

# 3.10 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels and tiles.

# 3.11 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install wall-type, fire department connections in vertical wall.
- B. Install ball drip valve at each check valve for fire department connection.

# 3.12 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.
- D. Connect piping to specialty valves, specialties, fire department connections, and accessories.
- E. Connect air compressor to the following piping and wiring:
  - 1. Pressure gages and controls.
  - 2. Electrical power system.
  - 3. Fire alarm devices, including low-pressure alarm.
- F. Electrical Connections: Power wiring is specified in Division 26.
- G. Connect alarm devices to fire alarm.
- H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

# 3.13 LABELING AND IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA.

#### 3.14 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 3. Energize circuits to electrical equipment and devices.
  - 4. Start and run air compressors.
  - 5. Flush, test, and inspect systems according to NFPA.
  - 6. Coordinate with fire alarm tests. Operate as required.
  - 7. Verify that equipment hose threads are same as local fire department equipment.
- B. Report test results promptly and in writing to Construction Manager and authorities having jurisdiction.

# 3.15 CLEANING AND PROTECTION

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.
- C. Protect sprinklers from damage until Substantial Completion.

# END OF SECTION 21 1000

# SECTION 22 0500 - COMMON WORK RESULTS FOR PLUMBING

# PART 1 - GENERAL

# 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Piping materials and installation instructions common to most piping systems.
  - 2. Dielectric fittings.
  - 3. Sleeve-seal systems.
  - 4. Sleeves.
  - 5. Stack-sleeve fittings.
  - 6. Escutcheons.
  - 7. Grout.
  - 8. Plumbing demolition.
  - 9. Equipment installation requirements common to equipment sections.
  - 10. Painting and finishing.
  - 11. Concrete bases.
  - 12. Supports and anchorages.

#### 1.2 ACTION SUBMITTALS

A. Product Data: For dielectric fittings.

# 1.3 QUALITY ASSURANCE

- A. Provide plumbing systems, equipment, and materials in accordance with applicable codes and regulations, and with authorities having jurisdiction.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

# 1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, handling, and up to substantial completion. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion.

# 1.5 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- B. Coordinate installation of required supporting devices and sleeves in structural components.
- C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

# 1.6 PROJECT COMMISSIONING

A. Project is attempting to obtain Leed Certification and has an independent commissioning authority (CxA). Contractors for this project shall meet CxA requirements and shall coordinate with and participate in commissioning activities.

# PART 2 - PRODUCTS

# 2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

# 2.2 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- C. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- D. Solvent Cements for Joining Plastic Piping:
  - 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

#### 2.3 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded end connections that match piping system materials.
  - 1. Insulating Material: Suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig(1725-kPa) minimum working pressure at 180 deg F(82 deg C) with threaded end connections.
- C. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig(2070-kPa) minimum working pressure at 225 deg F(107 deg C).
- D. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig(2070-kPa) minimum working pressure at 225 deg F(107 deg C).

# 2.4 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
  - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 2. Pressure Plates: Plastic.
  - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

# 2.5 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

# 2.6 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
  - 1. Underdeck Clamp: Clamping ring with setscrews.

# 2.7 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.
- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- E. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.
- F. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed or exposed-rivet hinge, and spring-clip fasteners.

# 2.8 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

#### 2.9 PLUMBING ROOF PENETRATIONS

- A. Pipe Curbs for Single or Multiple Pipe Penetrations: Prefabricated heavy-gage galvanized steel or aluminum curb with mitered and welded corners, minimum 1 1/2 inch thick rigid fiberglass insulation adhered to inside walls, built-in cant and mounting flange for roof decks, wood nailer, and acrylic clad ABS plastic cover(s), PVC boot(s), and stainless steel clamps.. Size as required to suit roof opening and piping. Overall minimum height shall be 12 inches above roof insulation. Pate or equivalent.
  - 1. Provide curbs with level tops and bottoms to match roof slope.
- B. Pipe Curbs for Single Pipe Penetrations: All roof pipe penetrations up to 10" O.D. shall be flashed and sealed using a Pate or equivalent pipe seal, consisting of a spun aluminum base having a minimum five inch roof surface flange, a stepped polyvinyl chloride boot to be secured to the base and the pipe with adjustable stainless steel clamps as furnished.
  - 1. Provide curbs with bottoms to match roof slope.

PART 3 - EXECUTION

# 3.1 PLUMBING DEMOLITION

- A. Refer to Division 01 Section "Execution" and Division 02 Section "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
  - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
  - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
  - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
  - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
  - 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.
- D. During domestic water demolition, eliminate all "dead-leg" sections.

# 3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
  - 1. Drawings are diagrammatic with no attempt made to show every ell, tee, transition, fitting, or appurtenance. Provide installations that are complete in every detail, compliant with all applicable codes, and as required to provide a fully functional and operational system even though every item is not specifically indicated.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.

- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.

# 3.3 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and finished floors according to the following:
  - 1. Escutcheons for New Piping:
    - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
    - c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
    - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
    - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or splitcasting brass type with polished, chrome-plated finish.
    - f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
    - g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
  - 2. Escutcheons for Existing Piping:
    - a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
    - b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge.
    - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    - e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chromeplated or rough-brass finish.
    - f. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated or rough-brass finish.

# 3.4 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
  - 1. Sleeves are not required for core-drilled holes.

- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1inch (25-mm) annular clear space between piping and concrete slabs and walls.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
  - 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
  - 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
  - Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 9200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

# 3.5 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
  - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
  - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 6200 "Sheet Metal Flashing and Trim."
  - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
  - Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
  - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

# 3.6 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

# 3.7 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
  - 1. Exterior Concrete Walls Above Grade:
    - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves, galvanized-steel wall sleeves, or galvanized-steel-pipe sleeves.
    - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves, galvanized-steel wall sleeve, or galvanized-steel-pipe sleeves.
  - 2. Exterior Concrete Walls below Grade:
    - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
    - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
  - 3. Concrete Slabs-on-Grade:
    - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
    - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
  - 4. Concrete Slabs above Grade:
    - a. Piping Smaller Than NPS 6 (DN 150): Stack-sleeve fittings.
    - b. Piping NPS 6 (DN 150) and Larger: Stack-sleeve fittings.
  - 5. Interior Partitions:
    - a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves.
    - b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-sheet sleeves.

# 3.8 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
  - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
  - 2. PVC Nonpressure Piping: Join according to ASTM D 2855.
- I. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

# 3.9 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
  - 1. Install unions, in piping NPS 2(DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2(DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
  - 3. Wet Piping Systems: Install dielectric unions, dielectric coupling, or dielectric nipple fittings to connect piping materials of dissimilar metals.

# 3.10 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Sequence, coordinate, and integrate installations of plumbing equipment.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
- E. Install equipment to allow right of way for piping installed at required slope.
- F. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
- G. Verify final equipment locations for roughing-in.
- H. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

#### 3.11 PAINTING

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

# 3.12 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
  - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches(100 mm) larger in both directions than supported unit.
  - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch(450-mm) centers around the full perimeter of the base.
  - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
  - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
  - 7. Use 3000-psi(20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 section for cast-in-place concrete."

# 3.13 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

### 3.14 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
  - 1. Clean surfaces that will come into contact with grout.
  - 2. Provide forms as required for placement of grout.
  - 3. Avoid air entrapment during placement of grout.
  - 4. Place grout, completely filling equipment bases.
  - 5. Place grout on concrete bases and provide smooth bearing surface for equipment.
  - 6. Place grout around anchors.
  - 7. Cure placed grout.

## 3.15 PLUMBING ROOF PENETRATIONS

- A. Install plumbing roof penetrations in accordance with roof curb manufacturer's recommendations and in strict compliance with roofing manufacturer's requirements.
  - 1. Roofs with Warranty: Roof penetrations and curbs shall be installed in such a manner to maintain roofing warranty.
- B. Pipe Curbs for Pipe Penetrations: Secure boot to curb base and secure boot to pipe with adjustable stainless steel clamps.

## 3.16 INSTALLATION OF ACCESS DOORS

- A. Where lay-in ceilings are used, the access to ceiling space is provided through the removable ceiling panels. Where access is required to valves, pipes, or other devices in spaces above non-removable ceilings or in chases, the Contractor requiring the access doors shall provide access doors. Access doors required in rated walls and ceiling shall bear the same rating. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
  - 1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
  - 2. Adjust hardware and panels after installation for proper operation.

## 3.17 FIELD QUALITY CONTROL

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

#### END OF SECTION 22 0500

## SECTION 22 0513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

#### 1.1 SUMMARY

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

## 1.2 COORDINATION

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

#### PART 2 - PRODUCTS

## 2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

## 2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet(1000 m) above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

## 2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.

- 1. Provide premium efficient motors where scheduled or when used with a variable frequency controller.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
  - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
  - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Class B.
- H. Insulation: Class F.
- I. Code Letter Designation:
  - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
  - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- J. Enclosure Material: Manufacturer's standard material.

# 2.4 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
  - 1. Permanent-split capacitor.
  - 2. Split phase.
  - 3. Capacitor start, inductor run.
  - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

# 2.5 ELECTRONIC COMMUTATION MOTOR (ECM)

A. Description: Motor to be an electronic commutation motor (ECM) specifically designed for direct drive applications. Motors shall be permanently lubricated with heavy-duty ball bearings to match the equipment

## PROJECT NO. 18-168.00 COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 22 0513 - 3 HRA 10/24/2019 PERMIT SET

load and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

PART 3 - EXECUTION (Not Applicable)

# END OF SECTION 22 0513

# SECTION 22 0519 - METERS AND GAGES FOR PLUMBING PIPING

- PART 1 GENERAL
- 1.1 SUMMARY
  - A. Section Includes:
    - 1. Thermometers.
    - 2. Gages.

# 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- 1.3 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.
- 1.4 QUALITY ASSURANCE
  - A. NSF Compliance as required by authorities having jurisdiction:
    - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
    - 2. Comply with NSF 61, "Drinking Water System Components Health Effects; Sections 1 through 9."
    - 3. Comply with NSF 372, "Drinking Water System Components Lead Content"

# PART 2 - PRODUCTS

# 2.1 LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ashcroft.
  - 2. Marsh Bellofram.
  - 3. Miljoco Corp.
  - 4. Trerice, H. O. Co.
  - 5. Weiss Instruments, Inc.
  - 6. Weksler Instruments.
- B. Case: Metal or plastic, 9 inches(229 mm) long.
- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.

- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass or plastic.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

# 2.2 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.
- C. Heat-Transfer Medium: Mixture of graphite and glycerin.

# 2.3 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ashcroft.
  - 2. Marsh Bellofram.
  - 3. Miljoco Corp.
  - 4. Trerice, H. O. Co.
  - 5. Weiss Instruments, Inc.
  - 6. Weksler Instruments.
- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
  - 1. Case: Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch(114-mm) diameter.
  - 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
  - 3. Pressure Connection: Brass, NPS 1/4(DN 8), bottom-outlet type unless back-outlet type is indicated.
  - 4. Movement: Mechanical, with link to pressure element and connection to pointer with front recalibration.
  - 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
  - 6. Pointer: Red or other dark-color metal.
  - 7. Window: Glass or plastic.
  - 8. Ring: Metal.
  - 9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
  - 10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure(100 kPa of vacuum to 103 kPa of pressure).
  - 11. Range for Fluids under Pressure: Two times operating pressure.

- C. Pressure-Gage Fittings:
  - 1. Valves: NPS 1/4(DN 8) brass ball type.
  - 2. Tubing: NPS 1/4(DN 8) copper.
  - 3. Snubbers: ASME B40.5, NPS 1/4(DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

# PART 3 - EXECUTION

## 3.1 THERMOMETER APPLICATIONS

- A. Install thermometers in the outlet of each domestic hot-water storage tank and elsewhere as indicated on drawings.
- B. Provide the following temperature ranges for thermometers:
  - 1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions(Minus 1 to plus 82 deg C, with 1-degree scale divisions).

# 3.2 GAGE APPLICATIONS

A. Install pressure gages for discharge of each pressure-reducing valve and elsewhere as indicated.

# 3.3 INSTALLATIONS

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
  - 1. Provide elbows as required to install gauges at location and angle readable from standing position on floor.
- D. Install ball valve and snubber fitting in piping for each pressure gage.
- E. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.
- F. Adjust faces of thermometers and gages to proper angle for best visibility.

#### END OF SECTION 22 0519

# SECTION 22 0523 – GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Bronze ball valves.
  - 2. Iron, lug type butterfly valves.
  - 3. Copper, grooved-end butterfly valves.
  - 4. Bronze swing check valves.
  - 5. Iron swing check valves.
- B. Related Sections:
  - 1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
  - 2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

## 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of valve indicated.
  - 1. Certification that products comply with NSF 61 Annex G and NSF 372.

#### 1.3 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
  - 1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  - 2. ASME B31.9 for building services piping valves.
- C. NSF Compliance as required by authorities having jurisdiction:
  - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
  - 2. Comply with NSF 61, "Drinking Water System Components Health Effects; Sections 1 through 9."
  - 3. Comply with NSF 372, "Drinking Water System Components Lead Content"

# 1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

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

## PART 2 - PRODUCTS

# 2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
  - 1. Handwheel: For valves other than quarter-turn types.
  - 2. Handlever: For quarter-turn valves NPS 6(DN 150) and smaller.
- E. Valves in Insulated Piping: Valves in domestic cold water lines with more than 1/2-inch(13-mm) insulation shall include the following:
  - 1. Ball Valves: Stem extensions or extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
  - 2. Butterfly Valves: Extended neck.
- F. Valve-End Connections:
  - 1. Flanged: With flanges according to ASME B16.1 for iron valves.
  - 2. Grooved: With grooves according to manufacturer.
  - 3. Solder Joint: With sockets according to ASME B16.18.
  - 4. Threaded: With threads according to ASME B1.20.1.

# 2.2 BRONZE BALL VALVES

- A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves.
    - b. Crane.
    - c. Hammond Valve.
    - d. Milwaukee Valve Company.
    - e. NIBCO INC.
    - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
  - 2. Description:
    - a. Standard: MSS SP-110.
    - b. CWP Rating: 600 psig(4140 kPa).
    - c. Body Design: Two piece, threaded.
    - d. Body Material: Bronze.
    - e. Ends: Threaded.
    - f. Seats: PTFE.
    - g. Stem: Bronze.
    - h. Ball: Bronze.
    - i. Port: Full.

# 2.3 IRON, LUG TYPE BUTTERFLY VALVES

- A. 200 CWP, Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves.
    - b. Crane.
    - c. DeZurik.
    - d. Hammond Valve.
    - e. Milwaukee Valve Company.
    - f. NIBCO INC.
    - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
  - 2. Description:
    - a. Standard: MSS SP-67.
    - b. CWP Rating: 200 psig(1380 kPa).
    - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    - d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
    - e. Seat: EPDM.
    - f. Stem: One- or two-piece stainless steel.
    - g. Disc: Aluminum bronze.

# 2.4 COPPER, GROOVED-END BUTTERFLY VALVES

- A. Copper, Grooved-End Butterfly Valves:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Anvil International, Inc.
    - b. Tyco / Grinnell.
    - c. Victaulic Company.
  - 2. Description:
    - a. Maximum Working Pressure: 300 psig(2070 kPa).
    - b. Body Material: Bronze or brass, lead free.
    - c. Stem: One or two-piece stainless steel.
    - d. Disc: Aluminum bronze or encapsulated ductile iron.
    - e. Seal: EPDM.

# 2.5 BRONZE SWING CHECK VALVES

- A. Class 125, Bronze Swing Check Valves with Bronze Disc:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves.
    - b. Crane.
    - c. Hammond Valve.
    - d. Milwaukee Valve Company.
    - e. NIBCO INC.
    - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
  - 2. Description:
    - a. Standard: MSS SP-139.
    - b. CWP Rating: 200 psig(1380 kPa).
    - c. Body Design: Horizontal flow.
    - d. Body Material: Bronze.
    - e. Ends: Threaded.
    - f. Disc: Bronze .

# 2.6 IRON SWING CHECK VALVES

- A. Class 150, Iron Swing Check Valves with Metal Seats:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves.
    - b. Crane.
    - c. Hammond Valve.

- d. Milwaukee Valve Company.
- e. NIBCO INC.
- f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
  - a. Standard: MSS SP-136.
  - b. CWP Rating: 250 psig(1724 kPa).
  - c. Body Design: Clear or full waterway.
  - d. Body Material: ASTM A 395, ductile iron with bolted bonnet.
  - e. Ends: Flanged.
  - f. Trim: Stainless steel.
  - g. Gasket: Asbestos free.

## PART 3 - EXECUTION

#### 3.1 EXAMINATION

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

## 3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install check valves for proper direction of flow.

## 3.3 ADJUSTING

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

# 3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. Valve Applications:
  - 1. Domestic Water:
    - a. Shutoff Service: Ball and butterfly valves.
    - b. Throttling Service: Ball and butterfly valves.
    - c. Check Valves:
      - 1) NPS 2(DN 50) and Smaller: Bronze swing check valves with nonmetallic disc.
      - 2) NPS 2-1/2(DN 65) and Larger: Iron swing type check valves with metal seat.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves with the following end connections:
  - 1. For Copper Tubing, NPS 2(DN 50) and Smaller: Threaded ends except where solder-joint valveend option is indicated in valve schedules below.
  - 2. For Copper Tubing, NPS 2-1/2 to NPS 4(DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
  - 3. For Grooved-End Copper Tubing: Valve ends may be grooved.

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

- A. Pipe NPS 2(DN 50) and Smaller:
  - 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
  - 2. Ball Valves: Two piece, full port, bronze with bronze trim.
  - 3. Bronze Swing Check Valves: Class 125, bronze disc.
- B. Pipe NPS 2-1/2(DN 65) and Larger:
  - 1. Iron, Lug-Style Butterfly Valves: 200 CWP, EPDM seat, aluminum-bronze disc.
  - Copper, Grooved-End Butterfly Valves: 300 psig maximum working pressure, aluminum-bronze or encapsulated disc.
  - 3. Iron Swing Check Valves: Class 150, metal seats.

# END OF SECTION 22 0523

## SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

## PART 1 - GENERAL

### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Metal pipe hangers and supports.
  - 2. Trapeze pipe hangers.
  - 3. Metal framing systems.
  - 4. Thermal-hanger shield inserts.
  - 5. Fastener systems.
  - 6. Pipe positioning systems.
- B. See Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers, and pipe and equipment supports.
- C. See Division 21 fire-suppression sections for pipe hangers for fire-suppression piping.

#### 1.2 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

#### 1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
  - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
  - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

# PART 2 - PRODUCTS

# 2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

# PROJECT NO. 18-168.00HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT<br/>HARBORCHASE OF FARMINGTON HILLS, MICHIGAN22 0529 - 2<br/>10/24/2019HRA10/24/2019

PERMIT SET

- 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
- 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
- 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- 4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

## 2.2 TRAPEZE PIPE HANGERS

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

# 2.3 METAL FRAMING SYSTEMS

- A. MFMA Manufacturer Metal Framing Systems:
  - 1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
  - 2. Standard: MFMA-4.
  - 3. Channels: Continuous slotted steel channel with inturned lips.
  - 4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
  - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Non-MFMA Manufacturer Metal Framing Systems:
  - 1. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
  - 2. Standard: Comply with MFMA-4.
  - 3. Channels: Continuous slotted steel channel with inturned lips.
  - 4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
  - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

# 2.4 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa) ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches(50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

## 2.5 FASTENER SYSTEMS

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

## 2.6 PIPE POSITIONING SYSTEMS

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

# 2.7 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
  - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
  - 2. Design Mix: 5000-psi(34.5-MPa), 28-day compressive strength.

# PART 3 - EXECUTION

# 3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use thermal-hanger shield inserts for insulated piping and tubing.
- G. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

# PROJECT NO. 18-168.00HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT<br/>HARBORCHASE OF FARMINGTON HILLS, MICHIGAN22 0529 - 4HRA10/24/2019

PERMIT SET

- 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30(DN 15 to DN 750).
- 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F(49 to 232 deg C) pipes, NPS 4 to NPS 16(DN 100 to DN 400), requiring up to 4 inches(100 mm) of insulation.
- 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24(DN 20 to DN 600), requiring clamp flexibility and up to 4 inches(100 mm) of insulation.
- 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
- 5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8(DN 15 to DN 200).
- 6. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30(DN 15 to DN 750).
- 7. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
- 8. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36(DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange.
- 9. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30(DN 25 to DN 750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.
- 10. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42(DN 50 to DN 1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
- H. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20(DN 20 to DN 500).
  - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20(DN 20 to DN 500), if longer ends are required for riser clamps.
- I. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches(150 mm) for heavy loads.
  - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F(49 to 232 deg C) piping installations.
- J. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
  - 2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  - 3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  - 4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  - 5. C-Clamps (MSS Type 23): For structural shapes.
  - 6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
  - 7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

a. Light (MSS Type 31): 750 lb(340 kg).

- b. Medium (MSS Type 32): 1500 lb(680 kg).
- c. Heavy (MSS Type 33): 3000 lb(1360 kg).
- 8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
  - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
  - 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- L. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches(32 mm).
  - 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
- M. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- N. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
  - 1. Use powder-actuated fasteners only in concrete construction that is suitable for their installation.

# 3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
  - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
  - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

- E. Fastener System Installation:
  - 1. Install powder-actuated fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
  - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- H. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, and at changes in direction of piping.
- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping: Comply with the following:
  - 1. Attach clamps and spacers to piping.
    - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
  - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
  - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
  - 4. Shield Dimensions for Pipe: Not less than the following:
    - a. NPS 1/4 to NPS 3-1/2(DN 8 to DN 90): 12 inches(305 mm) long and 0.048 inch(1.22 mm) thick.

## PROJECT NO. 18-168.00 HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 22 0529 - 7 HRA 10/24/2019 PERMIT SET

b. NPS 4(DN 100): 12 inches(305 mm) long and 0.06 inch(1.52 mm) thick.

- c. NPS 5 and NPS 6(DN 125 and DN 150): 18 inches(457 mm) long and 0.06 inch(1.52 mm) thick.
- d. NPS 8 to NPS 14(DN 200 to DN 350): 24 inches(610 mm) long and 0.075 inch(1.91 mm) thick.
- 5. Pipes NPS 8(DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts.]
- 6. Insert Material: Length at least as long as protective shield.
- 7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

# 3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

# 3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches(40 mm) maximum.

# 3.5 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils(0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

# END OF SECTION 22 0529

# SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Equipment labels.
  - 2. Pipe labels.
  - 3. Stencils.
  - 4. Valve tags.

# 1.2 ACTION SUBMITTALS

A. Valve Schedules: For each piping system.

## 1.3 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

#### 1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 "Pipe Labeling Guide" for color scheme, length of field and letter height.

# PART 2 - PRODUCTS

# 2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
  - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch(1.6 mm) thick, and having predrilled holes for attachment hardware.
  - 2. Letter Color: Black.
  - 3. Background Color: White.
  - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F(71 deg C).
  - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch(64 by 19 mm).

- a. Size of label shall be proportional to equipment size.
- 6. Minimum Letter Size: 1/4 inch(6.4 mm) for name of units if viewing distance is less than 24 inches(600 mm), 1/2 inch(13 mm) for viewing distances up to 72 inches(1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- 7. Fasteners: Stainless-steel rivets or self-tapping screws.
- 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number.

# 2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic label including flow arrow formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic label with contact-type, permanent-adhesive backing. Include flow arrow label with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service matching designations or abbreviations as used on Drawings.

# 2.3 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch(19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
  - 1. Stencil Material: Fiberboard or metal.
  - 2. Stencil Paint: Exterior, gloss, black enamel unless otherwise indicated. Paint may be in pressurized spray-can form.
  - 3. Identification Paint: Exterior enamel in colors according to ASME A13.1 unless otherwise indicated.

# 2.4 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch(6.4-mm) letters for piping system abbreviation and 1/2inch(13-mm) numbers.
  - 1. Tag Material: Brass, 0.032-inch(0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
  - 2. Fasteners: Brass wire-link or beaded chain; or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch(A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

## PROJECT NO. 18-168.00 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 220553 - 3 HRA 10/24/2019 PERMIT SET

- 1. Provide glass front frame for each valve schedule for mounting in building mechanical room.
- 2. Valve-tag schedule shall be included in operation and maintenance data.

# PART 3 - EXECUTION

### 3.1 PREPARATION

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

# 3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

## 3.3 PIPE LABEL INSTALLATION

- A. Pipe Label Applications: Install pipe labels as follows:
  - 1. Use pretensioned pipe labels or self-adhesive pipe labels.
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.
  - 1. Identification Paint: Use for contrasting background.
  - 2. Stencil Paint: Use for pipe marking.
- C. Locate pipe labels where piping is concealed above ceilings or exposed in unfinished mechanical rooms; accessible maintenance spaces such as shafts, tunnels, and plenums as follows:
  - 1. Near each valve and control device.
  - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
  - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
  - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
  - 5. Near major equipment items and other points of origination and termination.
  - 6. Spaced at maximum intervals of 50 feet(15 m) along each run.

# 3.4 VALVE-TAG INSTALLATION

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

# PROJECT NO. 18-168.00 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 220553 - 4 HRA 10/24/2019 PERMIT SET

B. Install glass front frame valve schedule in building mechanical room. Locate at Owners representative approved location.

END OF SECTION 22 0553

# SECTION 22 0700 - PLUMBING INSULATION

## PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section includes insulation materials for plumbing systems:
- B. Related Sections:
  - 1. Division 23 Section "HVAC Insulation."

# 1.2 ALTERNATES

- A. The Work of this Section is affected by alternates. Refer to Section 01 2300 "Alternates" for procedures for alternates.
- B. Alternate No. 2 Provide credit for deletion of insulation at cold water piping.

# 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated below. Include thermal conductivity, water-vapor permeance, thickness, and jackets (if any).
  - 1. Insulation Materials:
    - a. Mineral fiber.
    - b. Flexible elastomeric.
  - 2. Field-applied jackets.

#### 1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

## 1.5 DELIVERY, STORAGE, AND HANDLING

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

## 1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application.
  - 1. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

## 1.7 SCHEDULING

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

# PART 2 - PRODUCTS

# 2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- D. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Aeroflex USA, Inc.
    - b. Armacell LLC.
    - c. K-Flex USA.
- E. Mineral-Fiber, Preformed Pipe Insulation:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Johns Manville.

- b. Knauf Insulation.
- c. Manson Insulation Inc.
- d. Owens Corning.
- 2. Type I, 850 Deg F (454 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

# 2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
- B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

# 2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
  - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  - 1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
  - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- E. PVC Jacket Adhesive: Compatible with PVC jacket.
  - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

# 2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

- 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43mil (1.09-mm) dry film thickness.
- 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
- 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
- 4. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
  - 3. Solids Content: 60 percent by volume and 66 percent by weight.
  - 4. Color: White.

# 2.5 SEALANTS

- A. Joint Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Permanently flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
  - 4. Color: White or gray.
  - 5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Fire- and water-resistant, flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
  - 4. Color: White.
  - 5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

# 2.6 FACTORY-APPLIED JACKETS

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

# 2.7 FIELD-APPLIED JACKETS

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

- B. PVC Fitting Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
  - 1. Adhesive: As recommended by jacket material manufacturer.
  - 2. Color: White.
  - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
    - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, and mechanical joints.
- C. Self-Adhesive Outdoor Jacket: Minimum 40-mil-(1.0-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with aluminum-foil facing.
  - 1. Coordinate color of optional colors with Architect and Owner.
  - 2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Polyguard; Alumaguard.
    - b. MFM Building Products; Flex Clad 400

## 2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
  - 1. Width: 3 inches (75 mm).
  - 2. Thickness: 11.5 mils (0.29 mm).
  - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
  - 4. Elongation: 2 percent.
  - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
  - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive.
  - 1. Width: 2 inches (50 mm).
  - 2. Thickness: 6 mils (0.15 mm).
  - 3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
  - 4. Elongation: 500 percent.
  - 5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

#### 2.9 SECUREMENTS

- A. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- B. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
  - 1. Verify that systems to be insulated have been tested and are free of defects.
  - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.2 PREPARATION

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

# 3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  - 1. Install insulation continuously through hangers and around anchor attachments.
  - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

- 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
  - 1. Draw jacket tight and smooth.
  - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
  - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
    - a. For below-ambient services, apply vapor-barrier mastic over staples.
  - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
  - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. For above-ambient services, do not install insulation to the following:
  - 1. Vibration-control devices.
  - 2. Testing agency labels and stamps.
  - 3. Nameplates and data plates.
  - 4. Cleanouts.

# 3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations:
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation at roof structure and seal with joint sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

- C. Insulation Installation at Aboveground Exterior Wall Penetrations:
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant.
  - 3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 4. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches(50 mm).
  - 5. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
  - 1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
  - 1. Pipe: Install insulation continuously through floor penetrations.
  - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

# 3.5 GENERAL PIPE INSULATION INSTALLATION

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

two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

- 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
- 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
- 8. For mineral fiber insulation, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
- 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

# 3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 1. Flexible elastomeric pipe insulation only allowed in concealed or mechanical room locations.]
- B. Insulation Installation on Roof Drain Sumps:
  - 1. Install pipe insulation to bottom of roof drain sumps.
  - 2. Secure insulation to roof drain sumps and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Roof Drain Bodies:
  - 1. Install pipe insulation to bottom of roof drain bodies exposed within building.
  - 2. Secure insulation to roof drain bodies and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Pipe Flanges]:
  - 1. Install pipe insulation to outer diameter of pipe flange.
  - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

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

# 3.7 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
  - 1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
  - 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vaporbarrier mastic and joint sealant.
  - 3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
  - 4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
  - 1. Install preformed pipe insulation to outer diameter of pipe flange.
  - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
  - 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
  - 1. Install preformed sections of same material as straight segments of pipe insulation when available.
  - 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

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

## 3.8 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC fitting jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturers recommended adhesive.
  - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
  - 2. Fill inside of fitting jackets to prevent collapse of jacket.

## 3.9 FINISHES

- A. Paintable Jacket Material: Paint jacket with paint system identified in Division 09 painting Sections.
- 3.10 PIPING INSULATION SCHEDULE, GENERAL
  - A. Acceptable pipe insulation materials and thicknesses are identified for each piping system and pipe size range.
    - 1. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
  - B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
    - 1. Chrome-plated pipes and fittings.
    - 2. Underground piping.

# 3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
  - 1. NPS 1 (DN 25) and Smaller: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) thick.
    - b. Flexible Elastomeric: 1/2 inch (13 mm) thick.
  - 2. NPS 1-1/4 (DN 32) and Larger: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.

- b. Flexible Elastomeric: 1 inch (25 mm) thick.
- B. Domestic Hot and Recirculated Hot Water:
  - 1. NPS 1 (DN 25) and Smaller: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
    - b. Flexible Elastomeric: 1 inch (25mm) thick.
  - 2. NPS 1-1/4 (DN 32) and Larger: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch (38 mm) thick.
    - b. Flexible Elastomeric: 1-1/2 inch (38 mm) thick.
- C. Overflow Storm Water Internal of the Building:
  - 1. All Pipe Sizes: Vertical line up to drain body and all piping to point of building exit insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
- D. Overflow Storm Water External of the Building (Car Port):
  - 1. All Pipe Sizes: Insulation all piping with one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
    - b. Flexible Elastomeric: 1 inch(25 mm) thick.
- E. Storm Water Internal of the building:
  - 1. All Pipe Sizes: Vertical line up to drain body and horizontal runs within 30 Feet(9.1 m) of drain body insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
- F. Storm Water Internal of the building:
  - 1. All Pipe Sizes: Insulate all piping with the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
- G.
- a. Flexible Elastomeric: 1 inch(25 mm) thick.
- H. Roof Drain and Overflow Drain Bodies:
  - 1. All Pipe Sizes: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
    - b. Flexible Elastomeric: 1 inch(25 mm) thick.
- I. Roof Drain and Overflow Drain Pans:
  - 1. All Pipe Sizes: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
    - b. Flexible Elastomeric: 1 inch(25 mm) thick.
- J. Floor Drains, Traps, and Sanitary Drain Piping within 20 Feet(6 m) of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F(16 Deg C):
  - 1. All Pipe Sizes: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
    - b. Flexible Elastomeric: 1 inch (25 mm) thick.

## 3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Pipe Fittings with Mineral Fiber Insulation:
  - 1. PVC Fitting Covers: 20 mils(0.6 mm) thick, white.

## END OF SECTION 22 0700

#### SECTION 22 0800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes commissioning process requirements for plumbing systems, assemblies, and equipment.
- B. Related Sections:
  - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.
  - 2. Division 23 Section "Commissioning of HVAC Systems" for HVAC commissioning requirements.
  - 3. Division 26 Section "Commissioning of Electrical" for electrical systems commissioning requirements.

#### 1.2 DESCRIPTION OF COMMISSIONING

A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

#### 1.3 DEFINITIONS

A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

## 1.4 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
  - 1. Certificates of readiness
  - 2. Certificates of completion of installation, prestart, and startup activities.
  - 3. O&M manuals
  - 4. Test reports

#### 1.5 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

## 1.6 COORDINATION

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

## PART 2 - PRODUCTS

## 2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or 0.1°F. Pressure sensors shall have an accuracy of + or 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

## PART 3 - EXECUTION

## 3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. Red-Lined Drawings:
  - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
  - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
  - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
  - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data:

- 1. Contractor will provide a copy of O&M literature within 45 days of each submittal as requested by CxA.
- 2. The CxA will review the O&M literature once for conformance to project requirements.
- 3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.
- D. Demonstration and Training:
  - 1. Contractor will provide demonstration and training as required by the specifications.
  - 2. A complete training plan and schedule must be submitted by the contractor to the CxA.
  - 3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
  - 4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
- 3.2 CONTRACTOR'S RESPONSIBILITIES
  - A. Perform commissioning tests at the direction of the CxA.
  - B. Attend commissioning meetings as requested by CM and CxA.
  - C. Attend domestic water review and coordination meetings.
  - D. Participate in Plumbing systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
  - E. Provide information requested by the CxA for final commissioning documentation.
  - F. Prepare preliminary schedule for Plumbing system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe system testing, flushing and cleaning, equipment start-up, testing and task completion for owner. Distribute preliminary schedule to commissioning team members.
  - G. Update schedule as required throughout the construction period.
  - H. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.
  - I. Assist the CxA in all verification and functional performance tests.
  - J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
  - K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications.
  - L. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

- M. Coordinate and schedule all training with Owner personnel.
- N. Communicate all training with CM and CxA.
- O. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- P. Equipment Suppliers
  - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
  - 2. Assist in equipment testing per agreements with contractors.
  - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- Q. Refer to Division 01 Section "General Commissioning Requirements" for additional contractor responsibilities.
- 3.3 OWNER'S RESPONSIBILITIES
  - A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.
- 3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES
  - A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.
- 3.5 CxA'S RESPONSIBILITIES
  - A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

#### 3.6 TESTING PREPARATION

- A. Certify in writing to the CxA that Plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Plumbing instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Inspect and verify the position of each device and interlock identified on checklists.
- E. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

#### 3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- C. The CxA shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.
- D. Tests will be performed using design conditions whenever possible.
- E. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- F. The CxA may direct that set points be altered when simulating conditions is not practical.
- G. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- H. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- I. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

## 3.8 PLUMBING SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
  - 1. Domestic Water Heater Testing and Acceptance Procedures: Testing requirements are specified in Division 22 water heater Sections. Provide submittals, test data, inspection record, and heater certification to the CxA.
  - HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements for domestic water heater recirculation pump control and monitoring domestic water heater temperature specified in Division 23 Section "Sequence of Operations for HVAC Controls." Assist the CxA with preparation of testing plans.
  - 3. Domestic water pipe system cleaning, flushing, hydrostatic tests, and disinfecting requirements are specified in Division 22 piping Sections. Plumbing Installer shall prepare a pipe system cleaning, flushing, hydrostatic testing and disinfection plan. Provide cleaning, flushing, testing, and disinfection plan and final reports to the CxA. Plan shall include the following:
    - a. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be

physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and disinfection plan.

- b. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and disinfected.
- 4. The CxA shall determine the sequence of testing and testing procedures for each equipment item to be tested equipment and systems.
  - a. Domestic Water Boilers
  - b. Domestic Hot Water System
  - c. Elevator Sump Pump System
  - d. Gas System Natural Gas
  - e. Hot Water Circulating Pump
  - f. Hot Water Tempering Stations

# 3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

#### 3.10 APPROVAL

A. Refer to Division 01 Section "General Commissioning Requirements" for approval procedures.

## 3.11 DEFERRED TESTING

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.

## 3.12 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section "General Commissioning Requirements" for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

## 3.13 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to training.

## END OF SECTION 22 0800

#### SECTION 22 1116 - DOMESTIC WATER PIPING

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes domestic water piping inside the building.
- B. Related Sections include the following:
  - 1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and fittings.
  - 2. Division 22 Section "Domestic Water Piping Specialties" for water distribution piping specialties.

#### 1.2 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing domestic water piping systems with 125 psig (860 kPa), unless otherwise indicated.
- 1.3 INFORMATIONAL SUBMITTALS
  - A. Water Samples: Specified in Part 3 "Cleaning" Article.
  - B. Field quality-control test reports.

#### 1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61, "Drinking Water System Components Health Effects; Sections 1 through 9," for potable domestic water piping and components.
- C. Comply with NSF 372, "Drinking Water System Components Lead Content" for potable domestic water piping and components.

#### 1.5 REGULATORY REQUIREMENTS

- A. Comply with the provisions of the following:
  - 1. Michigan Plumbing Code.

PART 2 - PRODUCTS

#### 2.1 PIPING MATERIALS

- A. Refer to Part 3 "Pipe and Fitting Applications" Article for applications of pipe, tube, fitting, and joining materials.
- B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

#### 2.2 STAINLESS STEEL PIPING

- A. Stainless Steel Pipe: ASTM A 312, ASTM A778, Type 304 or 316, Schedule 10.
  1. Stainless Steel-Piping, Roled-End Fittings: ASTM A 304 or ASTM A312.
  - a. Couplings: ASTM A536 Grade 65-45-12 grad P gasket. Manufacturers: Subject to compliance with requirements, provide products from the following:
    1) Victaulic Company of America.

## 2.3 COPPER TUBE AND FITTINGS

- A. Soft Copper Tube: ASTM B 88, Types K (ASTM B 88M, Types A), water tube, annealed temper.
  - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
- B. Hard Copper Tube: ASTM B 88, Types L (ASTM B 88M, Types B), water tube, drawn temper.
  - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought- copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
  - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
  - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
  - 4. Copper, Grooved-End Fittings: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.
    - a. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, gasket suitable for domestic water, and bolts and nuts.
    - b. Manufacturers: Subject to compliance with requirements, provide products from the following:
      - 1) Victaulic Company of America.

- 2.4 PEX TUBE AND FITTINGS (Less than 125 deg. F water temperature)
  - A. PEX Distribution System: Crosslinked polyethylene (PEX), manufactured in accordance with ASTM F876 and ASTM F877.
    - 1. Fittings: ASTM F1960 metal cold expansion or ASTM F 1807, metal insert and crimp rings.
    - 2. Pressure/Temperature Rating: Minimum 100 psig(690 kPa) and 180 deg F(82 deg C).
    - 3. Provide pre-insulated PEX for underslab applications.
    - 4. Provide additional PEX piping saddle for all horizontal piping.
- 2.5 CPVC TUBE AND FITTINGS (Less than 125 deg. F water temperature)
  - A. CPVC Distribution System: Chlorinated polyvinyl chloride plastic pipe, manufactured in accordance with Table 605.4 of the Michigan Plumbing Code.
    - 1. Fittings: Manufactured in accordance with Table 605.5 of the Michigan Plumbing Code.
    - 2. Fittings pipe Connections: As Manufactured by Victaulic Company of America.
    - 3. Pressure/Temperature Rating: Minimum 100 psig(690 kPa) and 180 deg F(82 deg C).

## 2.6

## 2.7 MECHANICAL JOINT COPPER PRESS FITTING SYSTEM

- A. At the Installer's option, mechanical joint copper press fitting system using Type L copper tubing may be used for 2" inch and smaller above ground domestic water systems in lieu of soldered or threaded connections as specified.
- B. Provide manufacturer's standard mechanical joint copper press fittings and couplings which are suitable for the temperature range and operating pressures specified for each system and have the approval of state and local codes having jurisdiction.
- C. Fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for fittings shall be EPDM.
- D. Manufacturers: Subject to compliance with requirements, provide product by one of the following:
  - 1. Ridgid/Viega "ProPress"
  - 2. NIBCO "Press"
  - 3. Apollo "Xpress"

## 2.8 VALVES

- A. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- B. Balancing and drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

PART 3 - EXECUTION

## 3.1 EXCAVATION

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

## 3.2 PIPE AND FITTING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground piping, unless otherwise indicated.
- C. Grooved joints may be used on aboveground grooved-end piping.
- D. Under-Building-Slab, Water-Service Piping on Service Side of Water Meter: Refer to Division 22 Section "Facility Water Distribution Piping."
- E. Under Building Slab Domestic Water Piping to Island Sinks:
  - 1. Pre-Insulated PEX Tube; fittings for PEX tube; and crimped or cold expansion joints.
- F. Aboveground Domestic Water Piping: Use any of the following piping materials for each size range:
  - 1. NPS 1/4 (6.35mm) and Smaller for Dishwasher, Coffee Maker, and Refrigerator Final Connection: Soft copper tube, Type L (Type B); copper fittings; and soldered or compression joints.
  - 2. NPS 1 (DN 25) and Smaller: Hard copper tube, Type L (Type B); copper pressure fittings or soldered joints; PEX tubing and fittings.
  - 3. NPS 1-1/4 and NPS 1-1/2 (DN 32 and DN 40): Hard copper tube, Type L (Type B); copper pressure fittings; or soldered joints; PEX tubing and fittings.
  - 4. NPS 2 (DN 50): Hard copper tube, Type L (Type B); copper pressure fittings; or soldered joints; PEX tubing and fittings.
  - NPS 2-1/2 (DN 65): Hard copper tube, Type L (Type B) with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints; Stainless Steel with rolled-end fittings, CPVC piping with glued or grooved ends fittings.
  - 6. NPS 3 (DN 80): Hard copper tube, Type L (Type B) with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints; Stainless Steel and rolled-end fittings, CPVC piping with glued or grooved ends fittings.
  - 7. NPS 4 (DN 100): Hard copper tube, Type L (Type B) with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints Stainless Steel and rolled-end fittings, CPVC piping with glued or grooved ends fittings.

## 3.3 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

- 1. Shutoff Duty: Use bronze ball valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
- 2. Throttling Duty: Use bronze ball valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
- 3. Hot-Water-Piping, Balancing Duty: Calibrated balancing valves.
- 4. Drain Duty: Hose-end drain valves.
- B. Cast-iron, grooved-end valves may be used with grooved-end piping.
- C. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, on each water supply to plumbing fixtures that do not have supply stops and on each water supply to plumbing fixtures that do have supply stops but where take off from main or branch is not in the same room.
- D. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
  - 1. Install hose-end drain valves at low points in water mains, risers, and branches.
- E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Calibrated balancing valves are specified in Division 22 Section "Domestic Water Piping Specialties."

## 3.4 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."
- C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."
- D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Pressure gages are specified in Division 22 Section "Meters and Gages for Plumbing Piping," and drain valves and strainers are specified in Division 22 Section "Domestic Water Piping Specialties."
  - 1. Include a backflow preventer as required by local authority having jurisdiction.
- E. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

## 3.5 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

- B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- C. Grooved Joints: Assemble joints with grooved-end-pipe or grooved-end-tube coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- D. Press Connections: Copper press fitting connections shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer.
- E. PEX Piping Joints: Join according to ASTM F 1807 or ASTM F1960.
- F. CPVC Solvent Cementing: In accordance with Chapter 6 Water Supply and Distributing.

## 3.6 WATER METER INSTALLATION

- A. Rough-in domestic water piping for water meter connection according to utility company's requirements.
- B. Water meters will be furnished and installed by utility company.
- C. Install water meters according to AWWA M6 and utility's requirements.

#### 3.7 HANGER AND SUPPORT INSTALLATION

- A. Pipe hanger and support devices are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
  - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
  - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
    - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
  - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

- 1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
- 2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
- 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
- 4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
- 5. NPS 3 to NPS 4 (DN 80 to DN 100): 10 feet (3 m) with 1/2-inch (13-mm) rod.
- F. Install supports for vertical copper tubing every 10 feet (3 m).
- G. Install hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters.
  - 1. NPS 1-1/2 and NPS 2(DN 40 and DN 50): 48 inches(1200 mm) with 3/8-inch(10-mm) rod.
  - 2. NPS 3(DN 80): 48 inches(1200 mm) with 1/2-inch(13-mm) rod.
  - 3. NPS 4 and NPS 5(DN 100 and DN 125): 48 inches(1200 mm) with 5/8-inch(16-mm) rod.
  - 4. NPS 6(DN 150): 48 inches(1200 mm) with 3/4-inch(19-mm) rod.
- H. Install supports for vertical CPVC piping every 48"
- I. PEX Tubing: Install support of PEX Tubing per manufacturers requirements. Provide manufacturers piping saddle to support all PEX tubing.
- 3.8 Expansion and Contraction
  - A. Provide expansion and contraction as required by industry or manufacturers requirements.

## 3.9 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment and machines to allow service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

## 3.10 FIELD QUALITY CONTROL

- A. Inspect domestic water piping as follows:
  - 1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
  - 2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
    - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
    - b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

- 3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- 4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- B. Test domestic water piping as follows:
  - 1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
  - 2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
  - Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
  - 4. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
  - 5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
  - 6. Prepare reports for tests and required corrective action.

## 3.11 ADJUSTING

- A. Perform the following adjustments before operation:
  - 1. Close drain valves, hydrants, and hose bibbs.
  - 2. Open shutoff valves to fully open position.
  - 3. Open throttling valves to proper setting.
  - 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
  - 5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
  - 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
  - 7. Check plumbing specialties and verify proper settings, adjustments, and operation.

## 3.12 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
  - 1. Purge new domestic water piping before using.
  - 2. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
  - Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:
    - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    - b. Fill and isolate system according to either of the following:

- 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
- 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.
- c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
- d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- B. Prepare and submit reports of purging and disinfecting activities.

## END OF SECTION 22 1116

## **SECTION 22 1119 - DOMESTIC WATER PIPING SPECIALTIES**

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following domestic water piping specialties:
  - 1. Backflow preventers.
  - 2. Calibrated balancing valves.
  - 3. Temperature-actuated water mixing valves.
  - 4. Expansion Tanks
  - 5. Strainers.
  - 6. Outlet boxes.
  - 7. Hose bibbs.
  - 8. Wall hydrants.
  - 9. Roof hydrants.
  - 10. Drain valves.
  - 11. Water hammer arresters.
- B. Related Sections include the following:
  - 1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers and pressure gages in domestic water piping.
  - 2. Division 22 Section "Sanitary Waste Piping Specialties" for trap seal protection device.

## 1.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig(860 kPa), unless otherwise indicated.

#### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

## 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- 1.5 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

#### 1.6 QUALITY ASSURANCE

- A. NSF Compliance as required by authorities having jurisdiction:
  - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
  - 2. Comply with NSF 61, "Drinking Water System Components Health Effects; Sections 1 through 9."
  - 3. Comply with NSF 372, "Drinking Water System Components Lead Content"

## PART 2 - PRODUCTS

- 2.1 BACKFLOW PREVENTERS
  - A. Reduced-Pressure-Principle Backflow Preventers:
    - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - a. Ames Co.
      - b. Conbraco Industries, Inc.; Apollo Valves.
      - c. FEBCO; SPX Valves & Controls.
      - d. Watts Industries, Inc.; Water Products Div.
      - e. Zurn Plumbing Products Group; Wilkins Div.
    - 2. Standard: ASSE 1013.
    - 3. Operation: Continuous-pressure applications.
    - 4. Pressure Loss: 12 psig(83 kPa) maximum, through middle 1/3 of flow range.
    - 5. Body: Bronze for NPS 2(DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2(DN 65) and larger.
    - 6. End Connections: Threaded for NPS 2(DN 50) and smaller; flanged for NPS 2-1/2(DN 65) and larger.
    - 7. Accessories:
      - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2(DN 50) and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2(DN 65) and larger.
      - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
  - B. Beverage-Dispensing-Equipment Backflow Preventers:
    - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - a. Conbraco Industries, Inc.
      - b. Watts Industries, Inc.; Water Products Div.
      - c. Zurn Plumbing Products Group; Wilkins Div.
    - 2. Standard: ASSE 1022.
    - 3. Operation: Continuous-pressure applications.
    - 4. Size: NPS 1/4 or NPS 3/8(DN 8 or DN 10).
    - 5. Body: Stainless steel.

- 6. End Connections: Threaded.
- 2.2 CALIBRATED BALANCING VALVES
  - A. Copper-Alloy Calibrated Balancing Valves:
    - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - a. Bell & Gossett.
      - b. Taco, Inc.
      - c. Armstrong International, Inc.
      - d. Tour Andersson.
      - e. Apollo Valves.
    - 2. Type: Ball valve with two readout ports and memory setting indicator.
    - 3. Body: Bronze.
    - 4. Size: Same as connected piping, but not larger than NPS 2(DN 50).

## 2.3 TEMPERATURE-ACTUATED WATER MIXING VALVES

- A. Primary, Thermostatic, Water Mixing Valves:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Acorn Controls.
    - b. Apollo/Conbraco Industries, Inc.
    - c. Armstrong International, Inc.
    - d. Lawler Manufacturing Company, Inc.
    - e. Leonard Valve Company.
    - f. Powers; a Watts Industries Co.
    - g. Symmons Industries, Inc.
  - 2. Standard: ASSE 1017.
  - 3. Pressure Rating: 125 psig(860 kPa).
  - 4. Type: Exposed-mounting, thermostatically controlled water mixing valve.
  - 5. Material: Bronze body with corrosion-resistant interior components.
  - 6. Connections: Threaded union inlets and outlet.
  - 7. Accessories: Manual temperature control, dial thermometer, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
  - 8. Valve Pressure Rating: 125 psig(860 kPa) minimum, unless otherwise indicated.
  - 9. Valve Finish: Rough bronze.
  - 10. Piping Finish: Copper.
- B. Individual-Fixture, Water Tempering Valves:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Acorn Controls.
    - b. Cash Acme.

- c. Apollo/Conbraco Industries, Inc.
- d. Honeywell Water Controls.
- e. Lawler Manufacturing Company, Inc.
- f. Leonard Valve Company.
- g. Powers; a Watts Industries Co.
- h. Watts Industries, Inc.; Water Products Div.
- i. Zurn Plumbing Products Group; Wilkins Div.
- 2. Standard: ASSE 1070, thermostatically controlled water tempering valve.
- 3. Pressure Rating: 125 psig(860 kPa) minimum, unless otherwise indicated.
- 4. Body: Bronze or brass body with corrosion-resistant interior components.
- 5. Temperature Control: Adjustable.
- 6. Inlets and Outlet: Threaded with integral check valves.
- 7. Finish: Rough or chrome-plated bronze.
- 8. Tempered-Water Setting: 110 deg F(deg C).
- C. Emergency Shower and Eye-Wash Water Tempering Valves:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Acorn Controls.
    - b. Apollo/Conbraco Industries, Inc.
    - c. Lawler Manufacturing Company, Inc.
    - d. Leonard Valve Company.
    - e. Powers; a Watts Industries Co.
    - f. Watts Industries, Inc.; Water Products Div.
    - g. Speakman.
      - 1) Standard: ASSE 1071, thermostatically controlled water tempering valve.
      - 2) Standard: ANSI Z358.1.
      - 3) Pressure Rating: 125 psig(860 kPa) minimum, unless otherwise indicated.
      - 4) Body: Bronze body with corrosion-resistant interior components.
      - 5) Temperature Control: Adjustable.
      - 6) Inlets and Outlet: Threaded with integral checkstops.
      - 7) Finish: Rough or chrome-plated bronze.
      - 8) Tempered-Water Setting: 85 deg F(deg C).

## 2.4 EXPANSION TANKS

A. For heat exchanger domestic hot water systems, provide diaphragm type vertical ASME rated steel expansion tank of size and capacity as indicated, with precharged air cushion, heavy duty rubber diaphragm, charging valve, and rust resistant finish. Amtrol or equivalent.

## 2.5 STRAINERS FOR DOMESTIC WATER PIPING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ames.
  - 2. Apollo.
  - 3. Watts.
  - 4. Mueller

- 5. Wilkins.
- B. Y-Pattern Strainers:
  - 1. Pressure Rating: 125 psig(860 kPa) minimum, unless otherwise indicated.
  - 2. Body: Bronze .
  - 3. End Connections: Threaded for NPS 2(DN 50) and smaller; flanged for NPS 2-1/2(DN 65) and larger.
  - 4. Screen: Stainless steel with round perforations, unless otherwise indicated.
  - 5. Perforation Size:
    - a. StrainersNPS 2(DN 50) and Smaller: 0.020 inch(0.51 mm).
    - b. Strainers NPS 2-1/2 to NPS 4(DN 65 to DN 100): 0.062 inch(1.57 mm).
    - c. Strainers NPS 5(DN 125) and Larger: 0.10 inch(2.54 mm).
  - 6. Drain: Pipe plug for NPS 2(DN 50) and smaller; Factory-installed, hose-end drain valve for NPS 2-1/2(DN 65) and larger.

#### 2.6 OUTLET BOXES

- A. Ice Maker Outlet Boxes:
  - 1. Mounting: Recessed.
  - 2. Material and Finish: Enameled-steel or epoxy-painted-steel or plastic box and faceplate.
  - 3. Supply Shutoff Fittings: NPS 1/4(DN 7.5) quarter turn ball valve, chrome plated.
- B. Clothes Washer Outlet Boxes:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. IPS Corporation.
    - b. LSP Products Group, Inc
    - c. Oatey.
    - d. Plastic Oddities; a division of Diverse Corporate Technologies.
    - e. <u>Sioux Chief Manufacturing Company, Inc.</u>
  - 2. Mounting: Recessed.
  - 3. Material and Finish: Enameled-steel or epoxy-painted-steel or and faceplate.
  - 4. Faucet: Separate hot- and cold-water, valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
  - 5. Supply Shutoff Fittings: NPS 1/2(DN 15) gate, globe, or ball valves and NPS 1/2(DN 15) copper, water tubing.
  - 6. Drain: NPS 2(DN 50) standpipe and P-trap for direct waste connection to drainage piping.

## 2.7 HOSE BIBBS

- A. Close Coupled Wall Hydrant (Hose Bibb):
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Josam Company.
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.

- e. Watts Drainage Products Inc.
- f. Woodford Manufacturing Company.
- g. Zurn Plumbing Products Group.
- 2. Basis of Design: Woodford B75.
- 3. Pressure Rating: 125 psig(860 kPa).
- 4. Operation: Loose key.
- 5. Inlet: NPS 3/4 (DN 20).
- 6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
- 7. Box: Slim, flush mounting with cover.
- 8. Box and Cover Finish: Chrome plated.
- 9. Operating Keys(s): One with each wall hydrant.

## 2.8 WALL HYDRANTS

- A. Nonfreeze Wall Hydrants (NFWH):
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Josam Company.
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Woodford Manufacturing Company.
    - g. Zurn Plumbing Products Group.
  - 2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
  - 3. Pressure Rating: 125 psig(860 kPa).
  - 4. Operation: Loose key.
  - 5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
  - 6. Inlet: NPS 3/4 or NPS 1(DN 20 or DN 25).
  - 7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
  - 8. Box: Deep, flush mounting with cover.
  - 9. Box and Cover Finish nickel bronze.
  - 10. Box and Cover Finish: Chrome plated.
  - 11. Operating Keys: Two with each wall hydrant.

## 2.9 ROOF HYDRANTS

- A. Nonfreeze Roof Hydrants (NFRH):
  - 1. Manufacturers: Subject to compliance with requirements, provide products by Woodford Manufacturing Company or equivalent.
  - 2. Pressure Rating: 125 psig(860 kPa).
  - 3. Operation: Lever handle.
  - 4. Casing: NPS 1-1/4 (DN 30) galvanized pipe.
  - 5. Inlet: NPS 1(DN 25).
  - 6. Outlet: Integral ASSE 1052 double check backflow preventer with garden-hose thread connection.

- 7. Drain Connection: NPS 1/4(DN 8).
- 8. Hydrant Support: Cast iron with underdeck flange, mounting bolts, and well seal boot.

#### 2.10 DRAIN VALVES

- A. Ball-Valve-Type, Hose-End Drain Valves:
  - 1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
  - 2. Pressure Rating: 400-psig(2760-kPa) minimum CWP.
  - 3. Size: NPS 3/4(DN 20).
  - 4. Body: Copper alloy.
  - 5. Ball: Chrome-plated brass.
  - 6. Seats and Seals: Replaceable.
  - 7. Handle: Vinyl-covered steel.
  - 8. Inlet: Threaded or solder joint.
  - 9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.
- B. Gate-Valve-Type, Hose-End Drain Valves:
  - 1. Standard: MSS SP-80 for gate valves.
  - 2. Pressure Rating: Class 125.
  - 3. Size: NPS 3/4(DN 20).
  - 4. Body: ASTM B 62 bronze.
  - 5. Inlet: NPS 3/4(DN 20) threaded or solder joint.
  - 6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

#### 2.11 WATER HAMMER ARRESTERS

- A. Water Hammer Arresters:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Josam Company.
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  - 2. Standard: ASSE 1010 or PDI-WH 201.
  - 3. Type: Metal bellows.
  - 4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
  - 1. Locate backflow preventers in same room as connected equipment or system.
  - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
  - 3. Do not install bypass piping around backflow preventers.
- C. Install calibrated balancing valves in locations where they can easily be adjusted.
- D. Install primary temperature-actuated water mixing valves in accordance with manufacturer's requirements, and with shutoff valves on inlets and with shutoff valve on outlet.
- E. Install Y-pattern strainers for water on supply side of each inline pump and elsewhere as indicated.
- F. Install individual water tempering valves at each connection to barrier-free lavatories and sinks in accordance with manufacturers' recommendations and in compliance with the plumbing code and authority having jurisdiction.
- G. Install water hammer arresters in water piping according to PDI-WH 201.
- H. Install hose bibs with vacuum breaker on wall.
- I. Install nonfreeze wall hydrants with valve body within building, not within outside wall.
- J. Install nonfreeze roof hydrants with valve body within building, securely mounted to roof structure.
- K. Install expansion tanks at water heaters per manufacturers recommendations after piping has been pressure tested.
- L. Install vacuum breakers at each connection to commercial laundry equipment in accordance with manufacturers' recommendations and in compliance with the plumbing code and authority having jurisdiction. Locate in same room as equipment being connected and so they are easily accessible for maintenance and periodic testing.
- M. Install vacuum breakers at each connection to janitors closet soap dispenser in accordance with manufacturers' recommendations and in compliance with the plumbing code and authority having jurisdiction. Locate in same room as equipment being connected and so they are easily accessible for maintenance and periodic testing.

## 3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

## 3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:
  - 1. Test each backflow preventer according to authorities having jurisdiction and the device's reference standard.
  - 2. Test each domestic water piping specialty according to authorities having jurisdiction and the device's reference standard.
- B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

## 3.4 ADJUSTING

- A. Set field-adjustable flow set points of calibrated balancing valves.
- B. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

## END OF SECTION 22 1119

## SECTION 22 1123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic water circulation:
  - 1. In-line centrifugal booster pumps.
  - 2. Close-coupled, in-line, centrifugal pumps.
  - 3. Wet rotor circulator with ECM
  - 4. Separately coupled, horizontally mounted, in-line centrifugal pumps.
- B. Terminology used in this Section is from HI 1.1-1.2.

## 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. LEED Submittals:
  - 1. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1, without amendments, Section 7 "Service Water Heating."

## 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

## 1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. UL Compliance: Comply with UL 778 for motor-operated water pumps.
- D. NSF Compliance as required by authorities having jurisdiction:
  - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
  - 2. Comply with NSF 61, "Drinking Water System Components Health Effects; Sections 1 through 9."

- 3. Comply with NSF 372, "Drinking Water System Components Lead Content"
- 1.5 DELIVERY, STORAGE, AND HANDLING
  - A. Retain shipping flange protective covers and protective coatings during storage.
  - B. Protect bearings and couplings against damage.
  - C. Comply with pump manufacturer's written rigging instructions for handling.

## PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

#### 2.2 IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers:
  - 1. Bell & Gossett.
- B. Basis of Design: Bell & Gossett Model NBF.
- C. Description: Factory-assembled and -tested in-line horizontal system lubricated centrifugal pumps.
  - 1. Pump and Motor Assembly: Motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
  - 2. Casing: Lead-free bronze, with companion-flange connections.
  - 3. Motor Bearings: Carbon.
  - 4. Face Plate: Stainless steel.
  - 5. Impeller: Corrosion-resistant material.
  - 6. Shaft: Ceramic.
  - 7. Motor: Muiti-speed. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

## 2.3 CLOSE COUPLED, IN-LINE, CENTRIFUGAL PUMPS

- A. Manufacturers:
  - 1. Bell & Gossett.

- B. Basis of Design: Bell & Gossett Model PL.
- C. Description: Factory-assembled and -tested, single-stage, close-coupled, in-line, centrifugal pumps.
  - 1. Pump and Motor Assembly: Motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
  - 2. Casing: Bronze, with companion-flange connections.
  - 3. Face Plate: Stainless steel.
  - 4. Impeller: Corrosion-resistant material.
  - 5. Shaft: Carbon steel.
  - 6. Shaft Sleeve: Stainless steel.
  - 7. Seal: Mechanical, carbon on silicon carbide.
  - 8. Motor: Single speed, ODP, unless otherwise indicated. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."
  - 9. Motor Bearings: Sealed steel ball bearings, permanently lubricated.
  - 10. Elastomers: EPDM.

## 2.4 WET ROTOR INLINE PUMPS

- A. Manufacturers:
  - 1. Bell & Gossett.
- B. Basis of Design: Bell & Gossett Model ecocirc XL.
- C. Description: Factory-assembled and -tested, wet rotor in-line pumps with ECM motor and integrated variable frequency drive.
  - 1. Pump and Motor Assembly: Motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
  - 2. Casing: Lead-free bronze, with companion-flange connections.
  - 3. Impeller: Plastic or stainless steel.
  - 4. Shaft: Stainless steel.
  - 5. Rotor: Permanent magnet.
  - 6. Bearing: Carbon sleeve.
  - 7. Gasket/O-Ring: EPDM.
  - 8. All Other Wetted Parts: Stainless steel.
  - 9. Motor Type: Electronically commutated motor /permanent magnet and includes:
    - a. Class F motor insulation.
    - b. Integrated motor protection against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).
  - 10. Integrated Variable Frequency Drive: Tested as one unit by the manufacturer and includes:
    - a. MODBUS or BACnet connections built into the VFD as standard.
    - b. Analog inputs, such as 0-10V and 4-20mA inputs built into the VFD.
  - 11. Maximum Working Pressure: 175 psi.

12. Maximum Working Temperature: 230°F.

#### 2.5 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers:
  - 1. Bell & Gossett.
- B. Basis of Design: Bell & Gossett Series 60.
- C. Description: Factory-assembled and -tested, overhung-impeller, single-stage, separately coupled, horizontally mounted, in-line centrifugal pumps as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted horizontally.
  - 1. Pump Construction: All bronze or bronze fitted.
    - a. Casing: Radially split, cast iron, with threaded companion-flange connections or flanged connections.
    - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
    - c. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
    - d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
    - e. Pump Bearings: Permanently lubricated ball bearings.
  - 2. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
  - 3. Motor: Single speed, with grease-lubricated ball bearings; and resiliently mounted to pump casing. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

## 2.6 CONTROLS

- A. Thermostats: Electric; adjustable for control of hot-water circulation pump.
  - 1. Manufacturers:
    - a. Honeywell International, Inc.
    - b. Square D.
    - c. White-Rodgers Div.; Emerson Electric Co.
  - 2. Type: Strap-on sensor for installation on hot-water circulation piping.
  - 3. Operation of Pump: On or off.
  - 4. Power Requirement: 120 V, ac.
  - 5. Settings: Start pump at 100 deg F(38 deg C) and stop pump at 120 deg F(49 deg C).

PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.
- 3.2 PUMP INSTALLATION
  - A. Comply with HI 1.4.
  - B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- 3.3 CONTROL INSTALLATION
  - A. Install electric-type thermostats on hot-water return piping.

#### 3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
  - Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- F. Connect thermostats to pumps that they control.

## 3.5 STARTUP SERVICE

- A. Perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Check piping connections for tightness.
  - 3. Clean strainers on suction piping.

- 4. Set thermostats for automatic starting and stopping operation of pumps.
- 5. Perform the following startup checks for each pump before starting:
  - a. Verify bearing lubrication.
  - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
  - c. Verify that pump is rotating in the correct direction.
- 6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
- 7. Start motor.
- 8. Open discharge valve slowly.
- 9. Adjust temperature settings on thermostats.

## END OF SECTION 22 1123

## SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes soil and waste, sanitary drainage and vent piping inside the building.
- B. This Section includes soil and waste, sanitary drainage and vent piping inside the building and to a point five feet outside the building.
- C. This Section includes forced main waste piping inside the building.
- D. The following Sections contain related requirements:
  - 1. Division 22 Section "Sanitary Waste Piping Specialties" for soil, waste, and vent piping system specialties.

## 1.2 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
  - 1. Soil, Waste, and Vent Piping: 10-foot head of water(30 kPa).
  - 2. Forced Main Waste Piping: 50 psig (345 kPa).

## 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. LEED Submittal:
  - 1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

## 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control inspection and test reports.
- 1.5 QUALITY ASSURANCE
  - A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

## 1.6 REGULATORY REQUIREMENTS

- A. Comply with the provisions of the following:
  - 1. Michigan Plumbing Code.

## PART 2 - PRODUCTS

- 2.1 PIPING MATERIALS
  - A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.
  - B. Hub-and-Spigot, Cast-Iron Pipe and Fittings: ASTM A 74, Service class.
    - 1. Gaskets: ASTM C 564, rubber.
  - C. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 and CISPI 301.
    - 1. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
      - a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
  - D. Steel Pipe: ASTM A 53/A 53M, Type E, Schedule 40, galvanized. Include ends matching joining method.
    - 1. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.
      - a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
  - E. Solid-Wall PVC Pipe: ASTM D 2665, solid-wall drain, waste, and vent.
    - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

## PART 3 - EXECUTION

## 3.1 PIPING APPLICATIONS

- A. Aboveground, soil, waste, and vent piping NPS 1 1/2(DN 40) and smaller shall be any of the following:
  - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hublesscoupling joints.
  - 2. Steel pipe, drainage fittings, and threaded joints.
  - 3. PVC pipe, PVC socket fittings, and solvent-cemented joints.

- B. Aboveground, soil, waste, and vent piping NPS 2(DN 50) through NPS 10(DN 250) shall be any of the following:
  - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hublesscoupling joints.
  - 2. PVC pipe, PVC socket fittings, and solvent-cemented joints.
    - a. PVC above ground only allowed in concealed locations.
- C. Underground, soil, waste, and vent piping NPS 10(DN 250) and smaller shall be any of the following:
  - 1. Service class, hub-and-spigot, cast-iron soil pipe and fittings; gaskets; and compression joints.
  - 2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hublesscoupling joints.
  - 3. PVC pipe, PVC socket fittings, and solvent-cemented joints.
- D. Aboveground forced main piping shall be the following:
  - 1. PVC solid wall pipe, PVC socket fittings, and solvent-cemented joints.

#### 3.2 PIPING INSTALLATION

- A. Sanitary sewer piping outside the building is specified in Division 22 Section "Facility Sanitary Sewers."
- B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- C. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- D. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."
- E. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- F. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- G. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

- 1. Below slab sanitary drains shall be minimum 3-inch (76-mm) unless otherwise indicated with reducer down to above slab pipe size located at floor line.
- H. Install soil and waste drainage and vent piping at the minimum slopes required by plumbing code.
- I. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- J. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- K. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
- L. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

## 3.3 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
  - 1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
  - 2. Hubless Joints: Make with rubber gasket and sleeve or clamp.
- C. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
  - 1. For indoor applications, use PVC glue that has a VOC content of 510 g/L or less.
  - 2. For indoor applications, use PVC primer that has a VOC content of 550 g/L or less.

#### 3.4 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
  - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
  - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
    - a. 100 Feet(30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet(30 m): MSS Type 43, adjustable roller hangers.
  - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet(30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

- C. Support vertical piping at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch(10-mm) minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2(DN 40 and DN 50): 60 inches(1500 mm) with 3/8-inch(10-mm) rod.
  - 2. NPS 3(DN 80): 60 inches(1500 mm) with 1/2-inch(13-mm) rod.
  - 3. NPS 4 and NPS 5(DN 100 and DN 125): 60 inches(1500 mm) with 5/8-inch(16-mm) rod.
  - 4. NPS 6(DN 150): 60 inches(1500 mm) with 3/4-inch(19-mm) rod.
  - 5. NPS 8 to NPS 10(DN 200 to DN 250): 60 inches(1500 mm) with 7/8-inch(22-mm) rod.
  - 6. Spacing for 10-foot(3-m) lengths may be increased to 10 feet(3 m). Spacing for fittings is limited to 60 inches(1500 mm).
- F. Install supports for vertical cast-iron soil piping every 15 feet(4.5 m).
- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/4(DN 32): 84 inches(2100 mm) with 3/8-inch(10-mm) rod.
  - 2. NPS 1-1/2(DN 40): 108 inches(2700 mm) with 3/8-inch(10-mm) rod.
- H. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2(DN 40 and DN 50): 48 inches(1200 mm) with 3/8-inch(10-mm) rod.
  - 2. NPS 3(DN 80): 48 inches(1200 mm) with 1/2-inch(13-mm) rod.
  - 3. NPS 4 and NPS 5(DN 100 and DN 125): 48 inches(1200 mm) with 5/8-inch(16-mm) rod.
  - 4. NPS 6(DN 150): 48 inches(1200 mm) with 3/4-inch(19-mm) rod.
  - 5. NPS 8 to NPS 10(DN 200 to DN 250): 48 inches(1200 mm) with 7/8-inch(22-mm) rod.
- I. Install supports for vertical PVC piping every 48 inches(1200 mm).

#### 3.5 CONNECTIONS

- A. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- B. Connect drainage and vent piping to the following:
  - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to other Division 22 plumbing fixtures sections.
  - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
  - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Sanitary Waste Piping Specialties."
# 3.6 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 48 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
  - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
  - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction.
  - 1. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
  - 2. Prepare reports for tests and required corrective action.
- E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
  - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
  - 2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
  - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
  - 4. Prepare reports for tests and required corrective action.

# 3.7 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

# 3.8 PROTECTION

A. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

# END OF SECTION 22 1316

# **SECTION 22 1319 - SANITARY WASTE PIPING SPECIALTIES**

## PART 1 - GENERAL

### 1.1 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:
  - 1. Cleanouts.
  - 2. Floor drains.
  - 3. Trench drains.
  - 4. Trap-seal protection devices.
  - 5. Lint Interceptors.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
  - 1. Include rated capacities, operating characteristics, and accessories for grease interceptors.

#### 1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grease interceptors, to include in operation, and maintenance manuals.

#### 1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

## PART 2 - PRODUCTS

## 2.1 CLEANOUTS

- A. Exposed End of Pipe Cast-Iron Cleanouts:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Josam Company; Josam Div.
    - b. MIFAB, Inc.
    - c. Sioux Chief Mfg. Co.
    - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - e. Tyler Pipe; Wade Div.
    - f. Watts Drainage Products Inc.
    - g. Zurn Plumbing Products Group; Specification Drainage Operation.

- 2. Standard: ASME A112.36.2M.
- 3. Size: Same as connected drainage piping
- 4. Body Material: Hubless, cast-iron soil pipe as required to match connected piping.
- 5. Closure: Countersunk, brass plug.
- 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
- B. Cast-Iron Floor Cleanouts:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Josam Company; Josam Div.
    - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - c. Tyler Pipe; Wade Div.
    - d. Watts Drainage Products Inc.
    - e. Zurn Plumbing Products Group; Light Commercial Operation.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  - 2. Standard: ASME A112.36.2M for adjustable housing cleanout.
  - 3. Size: Same as connected branch.
  - 4. Type: Adjustable housing.
  - 5. Body or Ferrule: Cast iron.
  - 6. Outlet Connection: Spigot.
  - 7. Closure: Brass plug with straight threads and gasket.
  - 8. Adjustable Housing Material: Cast iron with threads.
  - 9. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
  - 10. Frame and Cover Type:
    - a. Ceramic, Mosaic & Quarry Tile Floors: Terrazzo top type with square nickel bronze top.
    - b. Asphalt & Vinyl Tile Floors: Tile top type with square nickel bronze top.
    - c. Terrazzo Floors: Terrazzo top type with round nickel bronze top.
    - d. Carpet Floors: Carpet flange type with round nickel bronze top.
    - e. Other Finished Floors: Heavy duty type with round nickel bronze top.
    - f. Unfinished Concrete Floors: Heavy duty type with round cast iron top.
- C. Cast-Iron Interior Finished Wall Cleanouts:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Josam Company; Josam Div.
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  - 2. Standard: ASME A112.36.2M. Include wall access.
  - 3. Size: Same as connected drainage piping.
  - 4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
  - 5. Closure: Countersunk, drilled-and-threaded brass plug.
  - 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

- 7. Wall Access: Round, flat, stainless-steel cover plate with screw.
- D. Cast-Iron Interior Unfinished Accessible Area Cleanouts:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Josam Company; Josam Div.
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Specification Drainage Operation.
  - 2. Standard: ASME A112.36.2M.
  - 3. Size: Same as connected drainage piping.
  - 4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
  - 5. Closure: Countersunk, drilled-and-threaded brass plug.
  - 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

### 2.2 FLOOR DRAINS

- A. Cast-Iron Floor Drains General:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Josam Company; Josam Div.
    - b. MIFAB, Inc.
    - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    - d. Tyler Pipe; Wade Div.
    - e. Watts Drainage Products Inc.
    - f. Zurn Plumbing Products Group; Light Commercial Operation.
    - g. Zurn Plumbing Products Group; Specification Drainage Operation.
  - 2. Standard: ASME A112.6.3.
- B. Cast Iron Floor Drains: Coated gray iron body having integral double drainage flange with weep holes and no-hub spigot or push-on bottom outlet. Provide flashing clamp device where located in membrane floor or when flashing is required for pans. Floor drain type designations and sizes are indicated on Drawings and scheduled below:
  - 1. FD-1: Toilet rooms and finished areas not specifically noted, "Wade" 1100G6 or equivalent with 6 inch (150 mm) square nickel bronze adjustable top, and plugged trap primer tap.
  - 1. FD-2: Mechanical room, receiving and storage room, "Wade" 1310TD or equivalent with 9 inch (225 mm) round ductile iron top, sediment bucket, and plugged trap primer tap.
  - 1. FD-3: Mechanical Room Floor sink, "Wade" 9110 8" x 8" x 6" (200 x 200 x 150 mm) or equivalent with removable cast iron grate, cast iron body, aluminum dome strainer at outlet, and plugged trap primer tap.

- 2. FD-4: Funnel type drains, finished areas, "Wade" 1100STD6-EF4 or equivalent with 6 inch (150 mm) round nickel bronze adjustable top, 4 inch (100 mm) round funnel, and plugged trap primer tap.
- 3. FD-5: Kitchen floor sink, "Wade" 9140 12" x 12" x 8" (300 x 300 x 200 mm) or equivalent with cast iron body, A.R.E. interior, aluminum dome strainer at outlet, 1/2 grate, and plugged trap primer tap.

# 2.3 TRAP SEAL PROTECTION DEVICES

- A. Barrier Type Trap Seal Protection Devices:
  - 1. Subject to compliance with requirements, provide SureSeal Manufacturing Inline Floor Drain Trap Sealer, MIFAB MI-GARD Trap Seal, or Jay R. Smith Model 2692 Trap Seal.
  - 2. Standard: ASSE 1072.
  - 3. Size: 2 inch (50 mm) thru 4 inch (100 mm) as required

# 2.4 MISCELLANEOUS DRAINAGE PIPING SPECIALTIES

1. Flow-Control Fitting: Integral or field installed.

## 2.5 LINT INTERCEPTOR

- A. lint Interceptors:
  - 1. Plastic Lint Interceptors:
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Ashland Trap Distribution Co.
      - 2) Green Turtle Zurn.
      - 3) Schier Products Company.
      - 4) Striem
      - 5) Town & Country Plastics, Inc.
      - 6) Zurn Industries, LLC.
  - Type: Factory-fabricated interceptor made for removing and retaining lint from cloth washers discharge water. Unit based on Striem Aardvark Series basket style solids interceptor or equal. Interceptor to be provided with removable gasketed cover, all perforated removable basket, low and high flow capabilities, field extendable basket handle.
    - a. Body Material: Polyethylene.
    - b. Basket: Removable perforated.
    - c. Liquid Capacity: 57 gallons
    - d. Solids Capacity: 8 gallons
    - e. Flow Rate: 75 GPM.
    - f. Inlet and Outlet Size: 4 inch(38 mm).
    - g. End Connections: Threaded.
    - h. Mounting: Flush with floor, provide extended riser as required for installation.
    - i. Cover rating: 2,000 lbs.

PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
  - 1. Install wall cleanouts in all finished spaces.
  - 2. Size same as drainage piping up to NPS 4(DN 100). Use NPS 4(DN 100) for larger drainage piping unless larger cleanout is indicated.
  - 3. Locate at each change in direction of piping greater than 45 degrees.
  - 4. Locate at minimum intervals of 50 feet(15 m) for piping NPS 4(DN 100) and smaller and 100 feet(30 m) for larger piping.
  - 5. Locate at base of each vertical soil and waste stack.
  - 6. For cleanouts at grade within 5'-0" of building install cleanouts and extension from drain pipe to cleanout at grade where indicated. Set cleanout in poured concrete block 18 inches by 18 inches by 12 inches deep, except where location is in concrete paving. Set top of cleanout 1 inch above surrounding earth grade or flush with grade when installed in paving.
  - 7. Align square tops parallel with building walls.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with cover flush with finished wall.
- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
  - 1. Position floor drains for easy access and maintenance.
  - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
  - 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
  - 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
  - 5. Align square tops parallel with floor tile.
- F. Install trap-seal protection devices at floor sink and floor drain outlets (omit at shower floor drains) during trim out stage of project.
- G. Install lint interceptors level and plumb, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.
  - 1. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.
  - 2. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

- H. Install solids interceptors below fixture being served in lieu of p-trap. Connect to sanitary drainage system. Locate and install to allow for access to unit and removal of integral basket.
- I. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- J. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

## 3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

## 3.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

#### 3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain grease interceptors.

## END OF SECTION 22 1319

# SECTION 22 1413 - FACILITY STORM DRAINAGE PIPING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes storm drainage piping inside the building.
- B. Related Sections include the following:
  - 1. Division 22 Section "Storm Drainage Piping Specialties" for storm drainage piping system specialties.

### 1.2 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
  - 1. Storm Drainage Piping: 10-foot head of water(30 kPa).

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. LEED Submittal:
  - 1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

#### 1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control inspection and test reports.

#### 1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

## 1.6 REGULATORY REQUIREMENTS

- A. Comply with the provisions of the following:
  - 1. Michigan Plumbing Code.

PART 2 - PRODUCTS

- 2.1 PIPING MATERIALS
  - A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.
  - B. Solid-Wall PVC Pipe: ASTM D 2665, solid-wall drain, waste, and vent.
    - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

## PART 3 - EXECUTION

### 3.1 PIPING APPLICATIONS

- A. Aboveground storm drainage piping NPS 2(DN 50) through NPS 10(DN 250) shall be any of the following:
  1. PVC pipe, PVC socket fittings, and solvent-cemented joints.
  - a. PVC above ground only allowed in concealed locations.
- B. Underground storm drainage piping NPS 10(DN 250) and smaller shall be any of the following:
  1. PVC pipe, PVC socket fittings, and solvent-cemented joints.

## 3.2 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties."
- C.
- D. Make changes in direction for storm piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- E. Lay buried building drain piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- F. Install storm drainage piping at the minimum slopes required by plumbing code.
- G. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

- H. Install above slab PVC storm drainage piping according to ASTM D 2665.
- I. Install underground PVC storm drainage piping according to ASTM D 2321.
- J. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

## 3.3 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
  - 1. For indoor applications, use PVC glue that has a VOC content of 510 g/L or less.
  - 2. For indoor applications, use PVC primer that has a VOC content of 550 g/L or less.

### 3.4 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
  - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
  - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
    - a. 100 Feet(30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet(30 m): MSS Type 43, adjustable roller hangers.
  - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet(30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch(10-mm) minimum rods.
- E. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2(DN 40 and DN 50): 48 inches(1200 mm) with 3/8-inch(10-mm) rod.
  - 2. NPS 3(DN 80): 48 inches(1200 mm) with 1/2-inch(13-mm) rod.
  - 3. NPS 4 and NPS 5(DN 100 and DN 125): 48 inches(1200 mm) with 5/8-inch(16-mm) rod.
  - 4. NPS 6(DN 150): 48 inches(1200 mm) with 3/4-inch(19-mm) rod.
  - 5. NPS 8 to NPS 10(DN 200 to DN 250): 48 inches(1200 mm) with 7/8-inch(22-mm) rod.
- F. Install supports for vertical PVC piping every 48 inches(1200 mm).

### 3.5 CONNECTIONS

- A. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- B. Connect storm drainage piping to roof drains and storm drainage specialties.

### 3.6 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 48 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
  - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
  - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction.
  - 1. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
  - 2. Prepare reports for tests and required corrective action.

## 3.7 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

# END OF SECTION 22 1413

## **SECTION 22 1423 - STORM DRAINAGE PIPING SPECIALTIES**

PART 1 - GENERAL

### 1.1 SUMMARY

- A. This Section includes the following storm drainage piping specialties:
  - 1. Cleanouts.
  - 2. Roof drains.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- 1.3 QUALITY ASSURANCE
  - A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- PART 2 PRODUCTS

## 2.1 CLEANOUTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Josam Company; Josam Div.
  - 2. MIFAB, Inc.
  - 3. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - 4. Sioux Chief Mfg. Co.
  - 5. Tyler Pipe; Wade Div.
  - 6. Watts Drainage Products Inc.
  - 7. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Exposed End of Pipe Cast-Iron Cleanouts:
  - 1. Standard: ASME A112.36.2M.
  - 2. Size: Same as connected drainage piping
  - 3. Body Material: Hubless, cast-iron soil pipe as required to match connected piping.
  - 4. Closure: Countersunk, brass plug.
  - 5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
- C. Cast-Iron Floor Cleanouts:
  - 1. Standard: ASME A112.36.2M for adjustable housing cleanout.
  - 2. Size: Same as connected branch.

- 3. Type: Adjustable housing.
- 4. Body or Ferrule: Cast iron.
- 5. Outlet Connection: Spigot.
- 6. Closure: Brass plug with straight threads and gasket.
- 7. Adjustable Housing Material: Cast iron with threads.
- 8. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
- 9. Frame and Cover Type:
  - a. Ceramic, Mosaic & Quarry Tile Floors: Terrazzo top type with square nickel bronze top.
  - b. Asphalt & Vinyl Tile Floors: Tile top type with square nickel bronze top.
  - c. Terrazzo Floors: Terrazzo top type with round nickel bronze top.
  - d. Carpet Floors: Carpet flange type with round nickel bronze top.
  - e. Other Finished Floors: Heavy duty type with round nickel bronze top.
  - f. Unfinished Concrete Floors: Heavy duty type with round cast iron top.
- D. Cast-Iron Interior Finished Wall Cleanouts:
  - 1. Standard: ASME A112.36.2M. Include wall access.
  - 2. Size: Same as connected drainage piping.
  - 3. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
  - 4. Closure: Countersunk, drilled-and-threaded brass plug.
  - 5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
  - 6. Wall Access: Round, flat, stainless-steel cover plate with screw.
- E. Cast-Iron Interior Unfinished Accessible Area Cleanouts:
  - 1. Standard: ASME A112.36.2M.
  - 2. Size: Same as connected drainage piping.
  - 3. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
  - 4. Closure: Countersunk, drilled-and-threaded brass plug.
  - 5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

# 2.2 ROOF DRAINS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Josam Company; Josam Div.
  - 2. MIFAB, Inc.
  - 3. Sioux Chief Mfg. Co.
  - 4. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - 5. Tyler Pipe; Wade Div.
  - 6. Watts Drainage Products Inc.
  - 7. Zurn Plumbing Products Group; Light Commercial Operation.
  - 8. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Cast-Iron Roof Drains General:
  - 1. Standard: ASME A112.21.2M.

- C. Cast Iron Roof Drains: Coated cast iron wide flange body, flashing ring/gravel stop, standard under deck clamp and cast iron dome strainer. Provide steel bearing pan in roof decks for added bearing surface area. Roof drain type designations and sizes are indicated on drawings and scheduled below:
  - 1. RD-1: General Roof Locations "Wade" 3000-52-53-DF or equivalent with cast iron dome, bearing pan, deck clamp, and extension flange.
    - a. Coordinate height of required extension flange with insulation thickness at each roof drain.
  - 2. RD-2: Combination Roof Drain/Overflow Drain Locations W-3041-42--DF with cast iron dome, bearing pan, 2-inch (50-mm) high dam, deck clamp, and extension flange.
    - a. Coordinate height of required extension flange with insulation thickness at each roof drain.
  - 3. RD-3: Overflow Drain Locations W-3000-52-53-D-DF with cast iron dome, bearing pan, 2-inch (50-mm) high dam, deck clamp, and extension flange.
    - a. Coordinate height of required extension flange with insulation thickness at each roof drain.
- D. Roof Drain Downspout Expansion Joints: "Wade 3900 Series or equivalent expansion joint for downspouts.
- E. Overflow Drain Downspout Cover: "Wade" 3941 or equivalent Chrome Plated, round with security flange and hinged grate, stainless steel screen.

## PART 3 - EXECUTION

# 3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
  - 1. Install wall cleanouts in all finished spaces.
  - 2. Size same as drainage piping up to NPS 4(DN 100). Use NPS 4(DN 100) for larger drainage piping unless larger cleanout is indicated.
  - 3. Locate at each change in direction of piping greater than 45 degrees.
  - 4. Locate at minimum intervals of 50 feet(15 m) for piping NPS 4(DN 100) and smaller and 100 feet(30 m) for larger piping.
  - 5. Locate at base of each vertical soil and waste stack.
  - 6. For cleanouts at grade within 2'-0" of building install cleanouts and extension from drain pipe to cleanout at grade where indicated. Set cleanout in poured concrete block 18 inches by 18 inches by 12 inches deep, except where location is in concrete paving. Set top of cleanout 1 inch above surrounding earth grade or flush with grade when installed in paving.

- 7. Align square tops parallel with building walls.
- C. For floor cleanouts for piping below floors in unfinished spaces or other spaces as indicated, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
  - 1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
  - 2. Position roof drains for easy access and maintenance.
  - 3. Install expansion joints in downspouts 25 feet or more in height, where horizontal offset is less than 5 feet.
- F. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- G. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
- H. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

#### 3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

## 3.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

## END OF SECTION 22 1423

## SECTION 22 3400 - FUEL-FIRED DOMESTIC WATER HEATERS

## PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following fuel-fired water heaters:
  - 1. Commercial, condensing storage gas water heaters.
  - 2. Expansion tanks.
  - 3. Water heater accessories.

#### 1.2 SUBMITTALS

- A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. LEED Submittals:
  - 1. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1, Section 7, "Service Water Heating."
- C. Shop Drawings: Diagram power, signal, and control wiring.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section.

## 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- 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. NSF Compliance as required by authorities having jurisdiction:
  - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
  - 2. Comply with NSF 61, "Drinking Water System Components Health Effects; Sections 1 through 9."
  - 3. Comply with NSF 372, "Drinking Water System Components Lead Content"

### 1.6 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

### 1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Leaks.
  - 2. Warranty Period(s): From date of Substantial Completion:
    - a. Water Heater: Three years.

#### 1.8 PROJECT COMMISSIONING

A. Project has an independent commissioning authority (CxA). Contractors for this project shall meet CxA requirements and shall coordinate with and participate in commissioning activities.

## PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

# 2.2 COMMERCIAL, GAS WATER HEATERS

A. Commercial, Condensing, Storage Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.

- 1. Manufacturers: Subject to compliance with requirements, provide Lochinvar "Shield" or an engineer approved equivalent product.
- 2. Description: Factory fired natural gas direct fired stainless steel heat exchanger mounted on top of storage tank. Manufacturer's proprietary design to provide at least 96 percent combustion efficiency at optimum operating conditions.
- 3. Storage-Tank Construction: Round vertical steel with 150-psig(1035-kPa) minimum workingpressure rating.
  - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
    - 1) NPS 2(DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
  - b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
  - c. Lining: Glass complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
- 4. Factory-Installed, Heater Appurtenances:
  - a. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
  - b. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
  - c. Jacket: Steel with enameled finish.
  - d. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
- 5. Burner: Premix design, constructed of high temperature stainless steel with woven metal fiber outer covering and variable speed blower.
- 6. Heat Exchanger: Natural gas direct fired stainless steel heat exchanger.
- 7. Temperature Control: Adjustable thermostat.
- 8. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
- 9. Energy Management System Interface: Normally closed dry contacts for enabling and disabling water heater.
- 10. Accessories:
  - a. Condensate neutralizing kit.
  - b. Concentric vent kit.
  - c. BACnet Communications

## 2.3 EXPANSION TANKS

- A. Diaphragm-Type Expansion Tanks:
  - 1. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butylrubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

- a. Manufacturers:
  - 1) AMTROL Inc.
  - 2) Armstrong Pumps, Inc.
  - 3) Bell and Gossett.
  - 4) Flexcon Industries.
  - 5) Honeywell Sparco.
  - 6) Myers, F. E.; Pentair Pump Group (The).
  - 7) Smith, A. O.; Aqua-Air Div.
  - 8) State Industries, Inc.
  - 9) Taco, Inc.
  - 10) Watts Regulator Co.
  - 11) Wessels Co.
- b. Construction:
  - 1) Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
  - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
  - 3) Air-Charging Valve: Factory installed.
  - 4) Working-Pressure Rating: 150 psig(1035 kPa).

## 2.4 WATER HEATER ACCESSORIES

- A. Vacuum Relief Valves: ANSI Z21.22 rated and CSA certified with all brass body and protective cap.
- B. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

## 2.5 VENTING KITS

A. Complete PVC venting system as indicated for combustion air intake and exhaust venting in accordance with manufacturer's requirements. Include terminals, thimbles, adapters, couplings, and sealant.

# 2.6 SOURCE QUALITY CONTROL

- A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test water heater storage tanks before shipment to minimum of one and one-half times pressure rating.
- C. Prepare test reports.

PART 3 - EXECUTION

- 3.1 WATER HEATER INSTALLATION
  - A. Install commercial water heaters on concrete bases.
    - 1. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
  - B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
  - C. Install gas water heaters according to NFPA 54.
  - D. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.
  - E. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
  - F. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.
  - G. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
  - H. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.
  - I. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.
  - J. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
  - K. Fill water heaters with water.
  - L. Charge diaphragm expansion tanks with air.
  - M. Install condensate neutralization kit. Include full initial charge of limestone.
  - N. Water Heater Venting:
    - 1. Install Stainless Steel venting exhaust venting and combustion-air intake per manufacturers requirements.

## 3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

## 3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

#### 3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain water heaters. Refer to Division 01 Section "Demonstration and Training."

## END OF SECTION 22 3400

## SECTION 22 4000 - PLUMBING FIXTURES

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes plumbing fixtures and related components.
- B. Related Sections include the following:
  - 1. Division 22 Section "Domestic Water Piping Specialties" for mixing valves and specialty fixtures not included in this Section.

### 1.2 DEFINITIONS

- A. Barrier-Free Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Piping and general-duty valves are included where indicated. Fittings specified in this Section include:
  - 1. Supplies and stops.
  - 2. Faucets and spouts.
  - 3. Drains and tailpieces.
  - 4. Traps and waste pipes.

#### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

# 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
  - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.
- B. Regulatory Requirements: Comply with the following:

- 1. Michigan Building Code (ANSI117) for plumbing fixtures for people with disabilities.
- 2. Michigan Plumbing Code.
- 3. Local authority having jurisdiction.
- 4. Michigan and local Department of Health requirements.
- C. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- D. NSF Compliance as required by authorities having jurisdiction:
  - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
  - 2. Comply with NSF 61, "Drinking Water System Components Health Effects; Sections 1 through 9."
  - 3. Comply with NSF 372, "Drinking Water System Components Lead Content"
- E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

## PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. Subject to compliance with specified requirements, provide commercial grade plumbing fixtures by one of the following:
  - 1. Lavatories, Water Closets, Urinals:
    - a. American Standard
    - b. Kohler
    - c. Zurn
    - d. Sloan
    - e. Mansfield
  - 2. Stainless Steel Sinks:
    - a. Elkay
    - b. Just
  - 3. Mop Basins:
    - a. Fiat
    - b. Florestone
    - c. Mustee
    - d. ProFlo
    - e. Swan
    - f. Zurn
  - 4. Faucets:
    - a. American Standard

- b. Chicago Faucet
- c. Delta
- d. Elkay
- e. Kohler
- f. Moen.
- g. T & S Brass
- h. Speakman
- i. Symmons
- j. Zurn
- 5. Flush Valves:
  - a. Sloan
  - b. Zurn
- 6. Water Closet Seats:
  - a. American Standard
  - b. Bemis
  - c. Centoco
  - d. Church
  - e. Kohler
  - f. Olsonite
  - g. ProFlo
  - h. Zurn
- 7. Water Coolers:
  - a. Elkay
  - b. Oasis
  - c. Halsey-Taylor
  - d. Haws
  - e. Murdock
- 8. Fixture Supports:
  - a. Josam
  - b. Wade
  - c. Zurn
  - d. Jay R. Smith
  - e. MIFAB
  - f. Watts.
- 2.2 WATER CLOSETS
  - A. WC-1 (Public ADA toilet) Floor Mount, white vitreous china, elongated bowl, Flush tank 28GPF, ADA height
    - 1. Fixture: American Standard Cadet Pro 215.M104 Right Height
    - 2. Seat: Centoco 500STSCC White solid plastic antimicrobial open front seat Bemis 1955CT white solid plastic open front seat with stainless steel check hinges and bolts.

- 3. Supply & Stop: McGuire LFBV2166CC
- B. WC-2 (ADA Public) Floor Mount, Manual flush valve elongated bowl vitreous china water closet, ADA Height
  - 1. Fixture: Kohler K-96057, 1.28GPF floor mount top spud flush valve WC.
  - 2. Flush Valve: Sloan 111-1.28 manual flush valve
  - 3. Seat: Centoco 500STSCC white solid plastic open front seat with stainless steel check hinges and bolts.
- C. WC-3 (Public ADA toilet) Floor Mount, white vitreous china, elongated bowl, Flush tank 1.28GPF, ADA height
  - 1. Fixture: American Standard Cadet Pro 215.M104 Right Height.
  - 2. Seat: Centoco 500STSCCC White solid plastic antimicrobial closed front seat with cover.
  - 3. Supply & Stop: McGuire LFBV2166CC

# 2.3 URINALS

- A. UR-1 Wall mount, high efficiency, white, wash down urinal
  - 1. Fixture: Kohler K-4991-ET-0, 0.125GPF wall mount vitreous china washout urinal.
  - 2. Flush Valve: Sloan Royal 186 SFSM-0.125-HW, 0.125GPF, hard wired sensor operated
  - 3. Fixture Height: ADA UNIT(UR1) 17" to rim, others(UR2) at 24" to rim.

## 2.4 LAVATORIES

- A. LAV-1 (Resident Rooms)- Integral counter lavatory with single handle manual faucet.
  - 1. Fixture: Integral to counter
  - 2. Faucet: Symmons S-20-2-G-W-0.5 Single Lever Faucet
  - 3. Drain: Pop up drain with 1 <sup>1</sup>/<sub>4</sub>" tailpiece.
  - 4. Trap: Tubular PVC Ptrap, 1 <sup>1</sup>/<sub>4</sub>" X 1 <sup>1</sup>/<sub>2</sub>".
  - 5. Supply & Stop: (2) McGuire 2165CC
  - 6. Mixing Valve: Powers LFe480-10 mixing valve.
- B. LAV-2 (Public and Spa)- Integral counter lavatory with single handle manual faucet.
  - 1. Fixture: Integral to counter
  - 2. Faucet: Kohler H-12182 Fairfax Single Lever Faucet, oil rubbed bronze finish
  - 3. Drain: McGuire 155A, drain with perforated strainer and 1 1/4" tailpiece.
  - 4. Trap: Tubular PVC Ptrap, 1 <sup>1</sup>/<sub>4</sub>" X 1 <sup>1</sup>/<sub>2</sub>".
  - 5. Supply & Stop: (2) McGuire 2165CC
  - 6. Trap Wrap: None Trap and supply behind shroud.
- C.

## 2.5 MOP BASINS

A. MB-1 Mop Basin: One piece molded stone 10" high basin with 2" shoulders 24" x 24" overall basin size. Furnish with factory installed 3" drain body with removable stainless steel strainer. Furnish with manufacture's standard mop hanger, two stainless steel wall shields, and hose and hose bracket

accessories for field installation. Mustee Model 63M or equivalent. Provide F-2 faucet as specified in the Articles below.

## 2.6 ELECTRIC WATER COOLERS

- A. EWC-1 Dual level electric water cooler with bottle filling stations
  - 1. Fixture: Elkay EZH2O model VRCGRNTL8WSK with Bottle Filling Station and Versatile Bi-Level ADA Cooler, filtered, 8 GPH, wall mount unit.
  - 2. Valve: ball valve

## 2.7 EMERGENCY EQUIPMENT

- A. EW/ES-1 Emergency Eye-Wash and Shower Station (Barrier-Free): Drench type with shower head, instant-action stay-open manually closed chrome plated brass ball shower valve with rigid stainless steel pull-rod and triangular handle, galvanized pipe standard with corrosion-resistant green coating and floor flange, corrosion-resistant eye/face-wash bowl with soft flow head(s), instant-action stay-open chrome plated brass ball eye-wash valve with push-flag operation. Placement of shower head, pull-rod, and eyewash bowl shall accommodate wheelchair user. Guardian Model GBF1909 or equivalent.
  - 1. Provide ANSI Z 358.1 compliant emergency equipment tempering thermostatic mixing valve on water lines to unit. Install valve in surface mounted wall cabinet.

#### 2.8 SINKS

- 1. Provide offset tailpiece on barrier-free units.
- 2. Provide thermostatic mixing valve on hot water line to barrier-free sink faucet. Mount below lavatory as high as possible. Refer to Section 22 1119 for mixing valve.
- 3. Provide plastic under lavatory trap and supplies insulation kit on barrier-free units. Refer to articles below.
- A. S1 (Resident Kitchen Sink) Single compartment undermount 18GA kitchen sink with single handle faucet
  - 1. Fixture: Wells Wentworth CMU2318-9 23x17.75x9 undermount sink
  - 2. Fixture: Wells Wentworth SSU2318-45 ADA undermount kitchen sink
  - 3. Faucet: Kohler K-596 Simplice pull down faucet, polished chrome
  - 4. Drain: Elkay LK-35 3-1/2" crumb cup stainer with 1-1/2"tailpiece
  - 5. Trap: McGuire 8912 1 <sup>1</sup>/<sub>2</sub>" x 1 <sup>1</sup>/<sub>2</sub>" chrome plated 17 gauge adjustable ground joint "P" trap and chrome deep pattern escutcheon.
  - 6 Supply & Stop: McGuire 2165CC <sup>1</sup>/<sub>2</sub>" chrome plated cast brass angle stops with wheel handle, 3/8" chrome plated flexible tube riser and chrome escutcheon.
  - 7 Mixing Valve: Powers LFe480-10 mixing valve.
- B. S2 (Med Sink)- Single compartment sink 15"x17"x5" 18gauge stainless steel sink, self rimming sink
  - 1. Fixture: Elkay LRAD151765 8" on center facet holes
  - 2. Faucet: Kohler K15075-P Coralais single lever handle faucet
  - 3. Drain: Elkay LK-35 3-1/2" crumb cup stainer with 1-1/2"tailpiece
  - 4. Trap: McGuire 8912 1 ½" x 1 ½" chrome plated 17 gauge adjustable ground joint "P" trap and chrome deep pattern escutcheon.

- 5. Supply & Stop: McGuire 2165CC <sup>1</sup>/<sub>2</sub>" chrome plated cast brass angle stops with wheel handle, 3/8" chrome plated flexible tube riser and chrome escutcheon.
- 6. Mixing Valve: Powers LFe480-10 mixing valve.
- C. S3 (Salon Sink) Counter mounted shampoo salon sink
  - 1. Fixture: Collins Manufacturing CB-23 Injection Molded Shampoo Sink w/ Collins Manufacturing 570 Chrome Lever Handle Faucet, spray hose
  - 2. Vacuum Breaker: Watts LFN388 Vacuum Breaker.
  - 3. Trap: McGuire 8912 1-1/2"x1-1/2" 17ga cast brass trap
  - 4. Supply & Stop: (2) McGuire LFBV2165CC.
  - 5. Mixing Valve: Powers LFe480-10 mixing valve.
- D. S4 (Activity/Multipurpose)- Under counter mounted 18GA stainless steel single compartment
  - 1. Fixture: Elkay ELUHAD2115 Lustertone Sink 21"x15"x5-3/8"
  - 2. Faucet: Kohler K-12177 Fairfax pull-out single lever handle faucet single hole installation
  - 3. Drain: Elkay LK-35 3-1/2" crumb cup stainer with 1-1/2"tailpiece
    - 4. Trap: McGuire 8912 1-1/2"x1-1/2" 17ga cast brass trap
    - 5. Supply & Stop: (2) McGuire LFBV2165CC.
    - 6. Mixing Valve: Powers LFe480-10 mixing valve.
- E. S5 (Laundry) Counter mounted 18 ga type 304 stainless steel single compartment sink with 3 faucet holes
  - 1. Fixture: Elkay LR2521 counter mounted Sink 25"x21"x7-7/8"
  - 2. Faucet: Chicago 201-G8AE35-317XKAB 1.5GPM gooseneck faucet with 8" on center wrist blade handles
  - 3. Drains: Elkay LK35
  - 4. Trap: McGuire 8912 1-1/2"x1-1/2" 17ga cast brass trap.
  - 5. Supply & Stop: (2) McGuire 2165CC.
  - 6. Mixing Valve: Powers LFe480-10 mixing valve.
  - C. S6 (Staff Breakroom)- Counter mounted 18GA stainless steel double compartment
    - 1. Fixture: Elkay PSRQ3319 drop in countertop sink
    - 2. Faucet: Symmons Unity SK-6600 pull-out single lever handle faucet
    - 3. Drain: Elkay LK-35 3-1/2" crumb cup stainer with 1-1/2"tailpiece
    - 4. Trap: McGuire 8912 1-1/2"x1-1/2" 17ga cast brass trap
    - 5. Supply & Stop: (2) McGuire LFBV2165CC.
    - 6. Mixing Valve: Powers LFe480-10 mixing valve.
- F. CS-1 Clinical Floor Mounted Sink: American Standard 95004 floor mounted service sink. Vitreous china, siphon jet flushing action, bolt caps, pedestal base.
  - a. Faucet: 48-inch- long rubber or vinyl hose, wall bracket and hook, and spray nozzle. Include supply stop; wall-mounting ASSE 1001 vacuum breaker; and polished chromeplated finish on metal parts exposed after installation. Chicago Faucet Model 809-CP or equivalent.
  - b. Foot Pedal Box: Brass floor mounted single foot pedal box, <sup>1</sup>/<sub>2</sub>" connections.
- 2.9 SHOWERS

- A. SH-1 SH1 (Resident Shower) 36"x60" fiberglass shower with ANSI grab bars and folding seat, pressure balanced mixing valve and hand shower.
  - 1. Enclosure: Aquatic 1603CFS with folding seat, curtain rod, and grab bars.
  - 2. Valve Symmons Origins 9603-PLR-TRM with temptrol Pressure balance valve, check stops, hand held spray, 30" bar, in line V.B.
  - 3. Sprayer Wall Mount: Provide additional sprayer mount for front wall.
  - 4. Drain 2"floor drain Sioux Chief model 842 with Stainless Steel grid drain.
  - 5. Options: Provide vinyl flexible
    - a. F-2 Service Faucet: Rough chrome plated cast brass, combination service sink fitting with vacuum breaker, 3/4" threaded hose spout, metal lever handles indexed "HOT" and "COLD" plus red and blue index tabs, wall brace, pail hook, adjustable flanged female supply arms and having integral stops. Chicago Faucet Model 897-RCF or equivalent.

## 7. FLUSH VALVES

- a. FV-1 Flush Valve: Quiet, exposed, chrome plated, diaphragm operated flush valve for 1.28 gallon water closets, with non-hold-open low force/ADA compliant handle; chloramine resistant, dual seal diaphragm with a clog resistant, minimum dual filtered by-pass; 1" I.P.S. screw driver operated combination angle check and stop valve with protective vandal resistant cap; sweat solder kit; adjustable tailpiece; cast wall flange with set screw; vacuum breaker; and spud coupling and flange for 1-1/2" top spud connection. Zurn Model Z6000AV-HET or equivalent.
- b. FV-2 Flush Valve: Quiet, exposed, chrome plated, diaphragm operated 0.125 gallon urinal flush valve, with non-hold open low force/ADA compliant handle; chloramine resistant, dual seal diaphragm with a clog resistant, minimum dual filtered by-pass; 3/4" I.P.S. screw driver angle stop with protective vandal resistant cap; sweat solder kit; adjustable tailpiece, cast wall flange, vacuum breaker; and spud coupling and flange for 3/4" top spud connection. Zurn Model Z6003AV-ULF or equivalent.
- c. FV-2 Flush Valve: Quiet, exposed, chrome plated, diaphragm operated 0.5 gallon urinal flush valve, with non-hold open low force/ADA compliant handle; chloramine resistant, dual seal diaphragm with a clog resistant, minimum dual filtered by-pass; 3/4" I.P.S. screw driver angle stop with protective vandal resistant cap; sweat solder kit; adjustable tailpiece, cast wall flange, vacuum breaker; and spud coupling and flange for 3/4" top spud connection. Zurn Model Z6003AV-EWS or equivalent.

### 8. SENSOR FAUCET AND FLUSH VALVE ACCESSORIES

- a. Provide flush valve hardwired power converters, mini junction boxes, and required low voltage wiring for power connection to sensor operated flush valves.
  - i. Include separate system for each toilet room.
- b. Provide faucet plug-in power converters and required low voltage wiring for power connection to sensor operated faucets.
  - i. Include separate system for each toilet room.

## 9. TOILET SEATS

a. TS-1 Elongated, heavy duty, solid white plastic toilet seats with molded-in bumpers, closed back/open front, less cover, and having stainless steel check hinge and stainless steel nuts. Centoco Model 500STSCC or equivalent.

### **10.FIXTURE SUPPORTS**

- a. General: All Fixture support carriers to conform to ANSI A112.6.1M (American National Standards Institute).
- b. **[Urinal and Water Cooler Support Carriers]**: Wade W-400-AM11-M36 or equivalent foot supported carrier with rectangular structural steel uprights, top support plate, and lower bearing plate with studs.
- c. Water Closet Support Carriers: Wade W-300 series or equivalent foot supported carrier with vertical or horizontal waste fitting configuration as required by waste piping installation. Single closet carriers shall be provided with rear anchoring foot. Closet coupling and fixture support rods shall be of proper length for wall thickness. M4 rod support feet shall be furnished when span from inside of finish block wall to face of carrier faceplate exceeds 6". M4 rod support feet shall also be provided on each water closet carrier installed on stud type wall construction.
- d. Lavatory Support Carriers: "Wade" Model W-520-M36 Series or equivalent concealed arm, foot supported carrier with rectangular structural steel uprights.

### 11.UNDER-LAVATORY GUARDS

a. Under-lavatory Shield-Type Guard:

- i. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Truebro by IPS Corporation; Lav-Shield.
  - 2. Zurn Industries, Inc.; Rigid Lavatory Enclosure Vandal Guard.
- ii. Description: One piece shield for covering supply and drain piping assemblies and other underlav mounted accessories to prevent direct contact with and to provide vandal resistance. Field trim to fit tightly to lavatory and adjacent surfaces.
- iii. Material and Finish: Rigid, high impact, stain resistant, molded PVC plastic, white.
- b. Under-Lavatory Guard:
  - i. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1. Plumberex Specialty Products, Inc.
    - 2. Truebro by IPS Corporation.
    - 3. ProFlo
  - ii. Description: Insulating pipe covering for supply and drain piping assemblies that prevent direct contact with and burns from piping; allow service access without removing coverings.
  - iii. Material and Finish: Antimicrobial, molded plastic, white.

## 12.FITTINGS, TRIM AND ACCESSORIES

- a. Fittings for Plumbing Fixtures: Fittings include the following:
  - i. Supply Inlets: Copper tube, size required for final connection.
  - ii. Supply Stops: Chrome-plated brass body, angle or straight configuration with compression fittings, loose-key type; size to match inlet pipe and supply riser.
  - iii. Supply Risers: 3/8-inch OD flexible chrome-plated brass tube with 1/2-inch IPS straight or offset, knob-end tailpiece[; or braided flexible stainless steel].
  - iv. Traps: Chrome-plated, 17 gauge tubular brass P-trap and wall bend, with slip-joint inlet, wall flange, and escutcheon; same size as fixture outlet connection.
    - 1. For concealed applications within water coolers or casework, ASTM F 409 PVC one or twopiece trap and waste to wall maybe used.

## 8 EXECUTION

### 1. EXAMINATION

- a. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
- b. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
- c. Proceed with installation only after unsatisfactory conditions have been corrected.

## 2. INSTALLATION

- a. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- b. Install off-floor supports, affixed to building substrate, for wallmounting fixtures.
  - i. Use carrier supports with waste fitting and seal for backoutlet fixtures.
  - ii. Use carrier supports without waste fitting for fixtures with tubular waste piping.
  - iii. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- c. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
- d. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
- e. Install wall-mounting fixtures with tubular waste piping attached to supports.
- f. Install counter-mounting fixtures in and attached to casework.
- g. Install fixtures level and plumb according to roughing-in drawings.
- h. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

- i. Exception: Use ball valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- i. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- j. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- k. Install toilet seats on water closets.
- I. Install traps on fixture outlets.
  - i. Exception: Omit trap on fixtures with integral traps.
  - ii. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- m. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deeppattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."
- n. Set mop basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."
- Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."
- p. Install flush valves in accordance with manufacturer's instructions. Adjust settings and verify proper operation.
  - i. Install flush valves on barrier-free units with handles on wide side of stall.
- q. Install under-lavatory insulation kits at [ barrier-free][ all] lavatory and sink locations in accordance with the following:
  - i. Cover hot- and cold-water supply risers, stops and handles, tailpiece, trap, and wall bend. Install in accordance with manufacturer's installation instructions. Trim connectors flush so no sharp edges remain.
- r. Install under-lavatory protective shield at[ barrier-free][ all] wall mounted lavatory locations in accordance with manufacturer's installation instructions.

## 3. CONNECTIONS

- a. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- b. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

## 4. FIELD QUALITY CONTROL

- a. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- b. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- c. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- d. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

## 5. ADJUSTING

- a. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- b. Adjust mixing valve maximum temperature limit stop in accordance with manufacturers' recommendations and in compliance with the plumbing code and authority having jurisdiction.
- c. Replace washers and seals of leaking and dripping faucets and stops.

## 6. CLEANING

- a. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
  - i. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
  - ii. Remove sediment and debris from drains.

b. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

# 7. PROTECTION

- a. Provide protective covering for installed fixtures and fittings.
- b. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

# 8. DEMONSTRATION

- a. Train Owner's maintenance personnel to adjust, operate, and maintain the following:
  - i. Faucets.
  - ii. Flush valves.
  - iii. Water coolers
  - iv. Drinking fountains
  - v. Shower valves.
  - vi. Washfountains.
- b. Refer to Division 01 Section "Demonstration and Training."

# 9. FIXTURE HEIGHT SCHEDULE

- a. Install fixtures to heights above finished floor as indicated.
  - i. Water Closet:
    - 1. Standard: 15 inches to top of bowl rim.
    - 2. Barrier Free: 17 to 19 inches, top of seat.
  - ii. Water Closet Flush Valves:
    - 1. Standard: 11 inches min. above bowl rim.
  - iii. Urinal:
    - 1. Standard: 22 inches to top of bowl rim.
    - 2. Barrier Free: 17 inches maximum to top of bowl rim.
  - iv. Urinal Flush Valves:
    - 1. Standard: 11 inches min. above top.

- 2. Barrier Free: 46 inches maximum to flush valve handle.
- v. Lavatory:
  - 1. Standard: 34 inches to top of basin rim.
  - 2. Barrier Free: 34 inches to top of basin rim.

## vi. Water Cooler:

- 1. Standard Adult: Minimum 38 inches and maximum 43 inches to spout outlet.
- 2. Barrier Free: Maximum 36 inches to spout outlet.

## **10.FIXTURE ROUGH-IN SCHEDULE**

- a. Line sizes indicated below are run-out sizes, reduce size as required at connection to fixture. Main lines and drops shall be installed in sizes as indicated on drawings.
  - i. Water Closet (Flush Valve Type):
    - 1. Cold Water: 1 Inch.
    - 2. Waste: 4 Inch.
    - 3. Vent: 2 Inch.
  - ii. Urinal (Flush Valve Type):
    - 1. Cold Water: 1 Inch.
    - 2. Waste: 2 Inch.
    - 3. Vent: 1-1/2 Inch.
  - iii. Lavatory:
    - 1. Hot Water: 1/2 Inch.
    - 2. Cold Water: 1/2 Inch.
    - 3. Waste: 1-1/2 Inch.
    - 4. Vent: 1-1/4 Inch.
  - iv. Sink:
    - 1. Hot Water: 1/2 Inch.
    - 2. Cold Water: 1/2 Inch.
    - 3. Waste: 2 Inch.
    - 4. Vent: 1-1/2 Inch.
  - v. Water Cooler:
    - 1. Cold Water: 1/2 Inch.
    - 2. Waste: 1-1/4 Inch.

3. Vent: 1-1/4 Inch.

vi. Mop Basin:

- 1. Hot Water: 3/4 inch.
- 2. Cold Water: 3/4 inch.
- 3. Waste: 3 inch.
- 4. Vent: 1-1/2 inch.

END OF SECTION 22 4000
# SECTION 23 0500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Piping materials and installation instructions common to most piping systems.
  - 2. Dielectric fittings.
  - 3. Sleeve-seal systems.
  - 4. Sleeves.
  - 5. Stack-sleeve fittings.
  - 6. Escutcheons.
  - 7. Grout.
  - 8. Equipment installation requirements common to equipment sections.
  - 9. Painting and finishing.
  - 10. Concrete bases.
  - 11. Supports and anchorages.
- B. Related Sections:
  - 1. Division 01 Section "Alternates" for requirements of alternates that relate to this Division.

# 1.2 ACTION SUBMITTALS

A. Product Data: For dielectric fittings.

### 1.3 QUALITY ASSURANCE

- A. Provide HVAC systems, equipment, and materials in accordance with Michigan Mechanical Code and other applicable codes and regulations, and with authorities having jurisdiction.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
  - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
  - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- D. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

# 1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, handling, and up to substantial completion. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion.

### 1.5 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- B. Coordinate installation of required supporting devices and sleeves in structural components.
- C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

## PART 2 - PRODUCTS

### 2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.
- C. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
  - 1. All castings used for coupling housings, fittings, valve bodies, etc., shall include listing/approval stamp, label, or other markings made to specified standards.

### 2.2 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
  - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch(3.2-mm) maximum thickness unless thickness or specific material is indicated.
    - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

### 2.3 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded end connections that match piping system materials.
  - 1. Insulating Material: Suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig(1725-kPa) minimum working pressure at 180 deg F(82 deg C) with threaded end connections.
- C. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig(2070-kPa) minimum working pressure at 225 deg F(107 deg C).
- D. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig(2070-kPa) minimum working pressure at 225 deg F(107 deg C).

# 2.4 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
  - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 2. Pressure Plates: Plastic.
  - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

# 2.5 SLEEVES

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

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

# 2.6 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
  - 1. Underdeck Clamp: Clamping ring with setscrews.

# 2.7 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.
- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- E. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.
- F. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed or exposed-rivet hinge, and spring-clip fasteners.

### 2.8 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

# 2.9 MECHANICAL ROOF PENETRATIONS

A. Roof Curbs for Duct Penetrations: Prefabricated heavy-gage galvanized steel or aluminum curb with mitered and welded corners, minimum 1 1/2 inch thick rigid fiberglass insulation adhered to inside walls, built-in cant and mounting flange for roof decks, and wood nailer. Size as required to suit roof opening and ductwork. Overall minimum height shall be 12 inches above roof insulation. Provide curbs with level tops and bottoms to match roof slope. Provide galvanized steel flashing and seal water tight. Provide insulation on interior flashing surfaces exposed to building air. Pate or equivalent.

- B. Pipe Curbs for Single or Multiple Pipe Penetrations: Prefabricated heavy-gage galvanized steel or aluminum curb with mitered and welded corners, minimum 1 1/2 inch thick rigid fiberglass insulation adhered to inside walls, built-in cant and mounting flange for roof decks, wood nailer, and acrylic clad ABS plastic cover(s), PVC boot(s), and stainless steel clamps.. Size as required to suit roof opening and piping. Overall minimum height shall be 12 inches above roof insulation. Provide curbs with level tops and bottoms to match roof slope. Pate or equivalent.
- C. Pipe Curbs for Single Pipe Penetrations: All roof pipe penetrations up to 10" O.D. shall be flashed and sealed using a Pate or equivalent pipe seal, consisting of a spun aluminum base having a minimum five inch roof surface flange, a stepped polyvinyl chloride boot to be secured to the base and the pipe with adjustable stainless steel clamps as furnished.

# PART 3 - EXECUTION

# 3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved.
  - 1. Drawings are diagrammatic with no attempt made to show every ell, tee, transition, fitting, or appurtenance. Provide installations that are complete in every detail, compliant with all applicable codes, and as required to provide a fully functional and operational system even though every item is not specifically indicated.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.

# 3.2 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and finished floors according to the following:
  - 1. Escutcheons for New Piping:
    - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
    - c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
    - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
    - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or splitcasting brass type with polished, chrome-plated finish.
    - f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
    - g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
  - 2. Escutcheons for Existing Piping:
    - a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
    - b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge.
    - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    - e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chromeplated or rough-brass finish.
    - f. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated or rough-brass finish.

# 3.3 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
  - 1. Sleeves are not required for core-drilled holes.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1inch (25-mm) annular clear space between piping and concrete slabs and walls.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.

- 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
  - 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
  - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 9200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

# 3.4 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
  - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
  - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 6200 "Sheet Metal Flashing and Trim."
  - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
  - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
  - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

## 3.5 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

# 3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
  - 1. Exterior Concrete Walls Above Grade:

- a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves, galvanized-steel wall sleeves, or galvanized-steel-pipe sleeves.
- b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves, galvanized-steel wall sleeve, or galvanized-steel-pipe sleeves.
- 2. Exterior Concrete Walls below Grade:
  - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
    - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
  - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves with sleeve-seal system.
    - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
- 3. Concrete Slabs-on-Grade:
  - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
    - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
  - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves with sleeve-seal system.
    - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
- 4. Concrete Slabs above Grade:
  - a. Piping Smaller Than NPS 6 (DN 150): Stack-sleeve fittings.
  - b. Piping NPS 6 (DN 150) and Larger: Stack-sleeve fittings.
- 5. Interior Partitions:
  - a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves.
  - b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-sheet sleeves.

# 3.7 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

# 3.8 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
  - 1. Install unions, in piping NPS 2(DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2(DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
  - 3. Wet Piping Systems: Install dielectric unions, dielectric couplings, or dielectric nipple fittings to connect piping materials of dissimilar metals.

# 3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Sequence, coordinate, and integrate installations of mechanical equipment, giving particular attention to large equipment requiring positioning prior to closing in the building.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
  - 1. Extend grease fittings to accessible locations.

- E. Install equipment to allow right of way for piping installed at required slope.
- F. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
- G. Verify final equipment locations for roughing-in.
- H. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

### 3.10 PAINTING

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

# 3.11 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
  - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches(100 mm) larger in both directions than supported unit.
  - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch(450-mm) centers around the full perimeter of the base.
  - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
  - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
  - 7. Use 3000-psi(20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 section for cast-in-place concrete.

# 3.12 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

### 3.13 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
  - 1. Clean surfaces that will come into contact with grout.

- 2. Provide forms as required for placement of grout.
- 3. Avoid air entrapment during placement of grout.
- 4. Place grout, completely filling equipment bases.
- 5. Place grout on concrete bases and provide smooth bearing surface for equipment.
- 6. Place grout around anchors.
- 7. Cure placed grout.

## 3.14 MECHANICAL ROOF PENETRATIONS

- A. Install mechanical roof penetrations in accordance with roof curb manufacturer's recommendations and in strict compliance with roofing manufacturer's requirements.
  - 1. Roofs with Warranty: Roof penetrations and curbs shall be installed in such a manner to maintain roofing warranty.
- B. Roof Curbs for Duct Penetrations: Provide galvanized steel flashing and seal water tight. Provide insulation on interior flashing surfaces exposed to building air.
- C. Pipe Curbs for Pipe Penetrations: Secure boot to curb base and secure boot to pipe with adjustable stainless steel clamps.

### 3.15 INSTALLATION OF ACCESS DOORS

- A. Where lay-in ceilings are used, the access to ceiling space is provided through the removable ceiling panels. Where access is required to valves, pipes, dampers or other devices in spaces above non-removable ceilings or in chases, the Contractor requiring the access doors shall provide access doors. Access doors required in rated walls and ceiling shall bear the same rating. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
  - 1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
  - 2. Adjust hardware and panels after installation for proper operation.

## 3.16 FIELD QUALITY CONTROL

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

## END OF SECTION 23 0500

### SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

### 1.1 SUMMARY

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

### 1.2 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
  - 1. Motor controllers.
  - 2. Torque, speed, and horsepower requirements of the load.
  - 3. Ratings and characteristics of supply circuit and required control sequence.
  - 4. Ambient and environmental conditions of installation location.
- B. For motors using variable frequency controller, motors to be designed for such application and suitable for use throughout speed range without overheating.

### PART 2 - PRODUCTS

### 2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

### 2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet(1000 m) above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

# 2.3 POLYPHASE MOTORS

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

- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
  - 1. Provide premium efficient motors where scheduled or when used with a variable frequency controller.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
  - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
  - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Class B.
- I. Insulation: Class F.
- J. Code Letter Designation:
  - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
  - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Manufacturer's standard material.

# 2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with controller.
  - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
  - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
  - 3. Shaft Grounding Ring: Factory installed shaft grounding ring consisting of maintenance free, circumferential, bearing protection ring with conductive micro fiber shaft contacting material.

### 2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
  - 1. Permanent-split capacitor.
  - 2. Split phase.
  - 3. Capacitor start, inductor run.

- 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

## 2.6 ELECTRONIC COMMUTATION MOTOR (ECM)

A. Description: Motor to be an electronic commutation motor (ECM) specifically designed for direct drive fan applications. Motors shall be permanently lubricated with heavy-duty ball bearings to match the fan load and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

PART 3 - EXECUTION (Not Applicable)

# END OF SECTION 23 0513

## SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Equipment labels.
  - 2. Pipe labels.
  - 3. Duct labels.
  - 4. Stencils.

## 1.2 ACTION SUBMITTALS

A. Valve Schedules: For each piping system.

### 1.3 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

### 1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 "Pipe Labeling Guide" for color scheme, length of field and letter height.

# PART 2 - PRODUCTS

### 2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
  - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch(1.6 mm) thick, and having predrilled holes for attachment hardware.
  - 2. Letter Color: Black.
  - 3. Background Color: White.
  - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F(71 deg C).
  - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch(64 by 19 mm).

- a. Size of label shall be proportional to equipment size.
- 6. Minimum Letter Size: 1/4 inch(6.4 mm) for name of units if viewing distance is less than 24 inches(600 mm), 1/2 inch(13 mm) for viewing distances up to 72 inches(1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- 7. Fasteners: Stainless-steel rivets or self-tapping screws.
- 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number.

# 2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic label including flow arrow formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic label with contact-type, permanent-adhesive backing. Include wrap around flow arrow tape with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service matching designations or abbreviations as used on Drawings.

# 2.3 DUCT LABELS

A. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings and an arrow indicating flow direction.

# 2.4 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches(32 mm) for ducts; and minimum letter height of 3/4 inch(19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
  - 1. Stencil Material: Fiberboard or metal.
  - 2. Stencil Paint: Exterior, gloss, black enamel unless otherwise indicated. Paint may be in pressurized spray-can form.
  - 3. Identification Paint: Exterior enamel in colors according to ASME A13.1 unless otherwise indicated.

PART 3 - EXECUTION

### 3.1 PREPARATION

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

# 3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

### 3.3 PIPE LABEL INSTALLATION

- A. Pipe Label Applications: Install pipe labels as follows:
  - 1. Use pretensioned pipe labels or self-adhesive pipe labels.
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.
  - 1. Identification Paint: Use for contrasting background.
  - 2. Stencil Paint: Use for pipe marking.
- C. Locate pipe labels where piping is concealed above ceilings or exposed in unfinished mechanical rooms; accessible maintenance spaces such as shafts, tunnels, and plenums as follows:
  - 1. Near each valve and control device.
  - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
  - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
  - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
  - 5. Near major equipment items and other points of origination and termination.
  - 6. Spaced at maximum intervals of 50 feet(15 m) along each run.
- D. Pipe Label Schedule:
  - 1. Refrigerant Piping:
    - a. Background Color: White
    - b. Letter Color: Black[.

# 3.4 DUCT LABEL INSTALLATION

- A. Stencil duct labels air ducts in the following color codes:
  - 1. Red: For Supply air ducts.
  - 2. Yellow: For Return air ducts.
  - 3. Blue: For outdoor air ducts

- 4. Green: For exhaust, outside-, relief air.
- 5. ASME A13.1 Colors and Designs: For hazardous material exhaust.

# END OF SECTION 23 0553

# SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Balancing Air Systems.
  - 2. Balancing Hydronic Piping Systems.
  - 3. Testing, Adjusting, and Balancing Equipment.

### 1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- B. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- C. System Readiness Checklists: Within 90 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- D. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- E. Certified TAB Reports: Submit four copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- F. Instrument calibration reports, to include the following:
  - 1. Instrument type and make.

- 2. Serial number.
- 3. Application.
- 4. Dates of use.
- 5. Dates of calibration.

## 1.4 QUALITY ASSURANCE

- A. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 "Air Balancing."

# 1.5 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Perform TAB after leakage and pressure tests on distribution systems have been satisfactorily completed.

# PART 2 - PRODUCTS (Not Applicable)

# PART 3 - EXECUTION

# 3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements, engage one of the following:
  - 1. Subject to compliance with requirements, provide the services of one of the following:
    - a. International Test and Balancing, Inc.
    - b. Quality Air Service, Inc.
    - c. Technical Energy Solutions.
    - d. Mechanical Testing Services, Inc.
    - e. Great Lakes Balancing
    - f. Aerodynamics Inspecting Co.

# 3.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine equipment performance data.
  - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
  - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- E. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- F. Examine test reports specified in individual system and equipment Sections.
- G. Examine HVAC equipment and verify that equipment with functioning controls is ready for operation.
- H. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- I. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- J. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- K. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- L. Examine system pumps to ensure absence of entrained air in the suction piping.
- M. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

### 3.3 PREPARATION

- A. Prepare a TAB plan that includes the following:
  - 1. Equipment and systems to be tested.
  - 2. Strategies and step-by-step procedures for balancing the systems.
  - 3. Instrumentation to be used.
  - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
  - 1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.

- b. Duct systems are complete with terminals installed.
- c. Volume, smoke, and fire dampers are open and functional.
- d. Clean filters are installed.
- e. Fans are operating, free of vibration, and rotating in correct direction.
- f. Variable-frequency controllers' startup is complete and safeties are verified.
- g. Automatic temperature-control systems are operational.
- h. Ceilings are installed.
- i. Windows and doors are installed.
- j. Suitable access to balancing devices and equipment is provided.
- 2. Hydronics:
  - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
  - b. Piping is complete with terminals installed.
  - c. Water treatment is complete.
  - d. Systems are flushed, filled, and air purged.
  - e. Strainers are pulled and cleaned.
  - f. Control valves are functioning per the sequence of operation.
  - g. Shutoff and balance valves have been verified to be 100 percent open.
  - h. Pumps are started and proper rotation is verified.
  - i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
  - j. Variable-frequency controllers' startup is complete and safeties are verified.
  - k. Suitable access to balancing devices and equipment is provided.

## 3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance"; ASHRAE 111; NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"; SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing"; and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
  - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
  - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 0700 "HVAC Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

# 3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 23 3113 "Metal Ducts."

### 3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
  - 1. Measure total airflow.
    - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
  - 2. Measure fan static pressures as follows:
    - a. Measure static pressure directly at the fan outlet or through the flexible connection.
    - b. Measure static pressure directly at the fan inlet or through the flexible connection.
    - c. Measure static pressure across each component that makes up the air-handling system.
    - d. Report artificial loading of filters at the time static pressures are measured.

- 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
- 4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
- 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
  - 1. Measure airflow of submain and branch ducts.
  - 2. Adjust submain and branch duct volume dampers for specified airflow.
  - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
  - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
  - 2. Measure inlets and outlets airflow.
  - 3. Adjust each inlet and outlet for specified airflow.
  - 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
  - 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
  - 2. Re-measure and confirm that total airflow is within design.
  - 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
  - 4. Mark all final settings.
  - 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
  - 6. Measure and record all operating data.
  - 7. Record final fan-performance data.
    - а. :

# 3.7 PROCEDURES FOR MOTORS

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

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

# 3.8 PROCEDURES FOR VRF CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.
- D. Measure, adjust, and record the following data for each refrigerant coil:
  - 1. Dry-bulb temperature of entering and leaving air.
  - 2. Wet-bulb temperature of entering and leaving air.
  - 3. Airflow.

### 3.9 TOLERANCES

- A. Set HVAC system's flow rates within the following tolerances:
  - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
  - 2. Air Outlets and Inlets: Plus or minus 10 percent.
  - 3. Heating-Water Flow Rate: Plus or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

### 3.10 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

### 3.11 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
  - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
  - 2. Include a list of instruments used for procedures, along with proof of calibration.
  - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:

- 1. Equipment operating curves.
- 2. Manufacturers' test data.
- 3. Field test reports prepared by system and equipment installers.
- 4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
  - 1. Title page.
  - 2. Name and address of the TAB specialist.
  - 3. Project name.
  - 4. Project location.
  - 5. Engineer's name and address.
  - 6. Contractor's name and address.
  - 7. Report date.
  - 8. Signature of TAB supervisor who certifies the report.
  - 9. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
  - 10. Summary of contents including the following:
    - a. Indicated versus final performance.
    - b. Notable characteristics of systems.
    - c. Description of system operation sequence if it varies from the Contract Documents.
  - 11. Nomenclature sheets for each item of equipment.
  - 12. Data for terminal units, including manufacturer's name, type, size, and fittings.
  - 13. Notes to explain why certain final data in the body of reports vary from indicated values.
  - 14. Test conditions for fans and pump performance forms including the following:
    - a. Settings for outdoor-, return-, and exhaust-air dampers.
    - b. Conditions of filters.
    - c. Cooling coil, wet- and dry-bulb conditions.
    - d. Face and bypass damper settings at coils.
    - e. Fan drive settings including settings and percentage of maximum pitch diameter.
    - f. Inlet vane settings for variable-air-volume systems.
    - g. Settings for supply-air, static-pressure controller.
    - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
  - 1. Quantities of outdoor, supply, return, and exhaust airflows.
  - 2. Water flow rates.
  - 3. Duct, outlet, and inlet sizes.
  - 4. Pipe and valve sizes and locations.
  - 5. Terminal units.
  - 6. Balancing stations.
  - 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

- 1. Unit Data:
  - a. Unit identification.
  - b. Location.
  - c. Make and type.
  - d. Model number and unit size.
  - e. Manufacturer's serial number.
  - f. Unit arrangement and class.
  - g. Discharge arrangement.
  - h. Variable frequency drive information.
  - i. Sheave make, size in inches (mm), and bore.
  - j. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
  - k. Number, make, and size of belts.
  - I. Number, type, and size of filters.
- 2. Motor Data:
  - a. Motor make, and frame type and size.
  - b. Horsepower and rpm.
  - c. Volts, phase, and hertz.
  - d. Full-load amperage and service factor.
  - e. Sheave make, size in inches (mm), and bore.
  - f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
- 3. Test Data (Indicated and Actual Values):
  - a. Total airflow rate in cfm (L/s).
  - b. Total system static pressure in inches wg (Pa).
  - c. Fan rpm.
  - d. Discharge static pressure in inches wg (Pa).
  - e. Filter static-pressure differential in inches wg (Pa).
  - f. Preheat-coil static-pressure differential in inches wg (Pa).
  - g. Cooling-coil static-pressure differential in inches wg (Pa).
  - h. Heating-coil static-pressure differential in inches wg (Pa).
  - i. Outdoor airflow in cfm (L/s).
  - j. Return airflow in cfm (L/s).
  - k. Return-air damper position.
  - I. Variable frequency drive information.
  - m. Preheat-coil static-pressure differential in inches wg (Pa).
  - n. Cooling-coil static-pressure differential in inches wg (Pa).
  - o. Heating-coil static-pressure differential in inches wg (Pa).
- F. Apparatus-Coil Test Reports:
  - 1. Coil Data:
    - a. System identification.
    - b. Location.
    - c. Coil type.
    - d. Number of rows.

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

- b. Total system static pressure in inches wg (Pa).
- c. Fan rpm.
- d. Discharge static pressure in inches wg (Pa).
- e. Suction static pressure in inches wg (Pa).
- H. Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
  - 1. Report Data:
    - a. System and air-handling-unit number.
    - b. Location and zone.
    - c. Traverse air temperature in deg F (deg C).
    - d. Duct static pressure in inches wg (Pa).
    - e. Duct size in inches (mm).
    - f. Duct area in sq. ft. (sq. m).
    - g. Indicated airflow rate in cfm (L/s).
    - h. Indicated velocity in fpm (m/s).
    - i. Actual airflow rate in cfm (L/s).
    - j. Actual average velocity in fpm (m/s).
    - k. Barometric pressure in psig (Pa).
- I. Air-Terminal-Device Reports: Including Concealed VRF Units and Ductless Split System.
  - 1. Unit Data:
    - a. System and air-handling unit identification.
    - b. Location and zone.
    - c. Apparatus used for test.
    - d. Area served.
    - e. Make.
    - f. Number from system diagram.
    - g. Type and model number.
    - h. Size.
    - i. Effective area in sq. ft. (sq. m).
  - 2. Test Data (Indicated and Actual Values):
    - a. Airflow rate in cfm (L/s).
    - b. Air velocity in fpm (m/s).
    - c. Preliminary airflow rate as needed in cfm (L/s).
    - d. Preliminary velocity as needed in fpm (m/s).
    - e. Final airflow rate in cfm (L/s).
    - f. Final velocity in fpm (m/s).
    - g. Space temperature in deg F (deg C).
- J. Compressor and Condenser Reports: For refrigerant side of air-cooled condensing units, include the following:
  - 1. Unit Data:

- a. Unit identification.
- b. Location.
- c. Unit make and model number.
- d. Compressor make.
- e. Compressor model and serial numbers.
- f. Refrigerant weight in lb(kg).
- g. Low ambient temperature cutoff in deg F(deg C).
- 2. Test Data (Indicated and Actual Values):
  - a. Inlet-duct static pressure in inches wg(Pa).
  - b. Outlet-duct static pressure in inches wg(Pa).
  - c. Entering-air, dry-bulb temperature in deg F(deg C).
  - d. Leaving-air, dry-bulb temperature in deg F(deg C).
  - e. Control settings.
  - f. Unloader set points.
  - g. Low-pressure-cutout set point in psig(kPa).
  - h. High-pressure-cutout set point in psig(kPa).
  - i. Suction pressure in psig(kPa).
  - j. Suction temperature in deg F(deg C).
  - k. Condenser refrigerant pressure in psig(kPa).
  - I. Condenser refrigerant temperature in deg F(deg C).
  - m. Oil pressure in psig(kPa).
  - n. Oil temperature in deg F(deg C).
  - o. Voltage at each connection.
  - p. Amperage for each phase.
  - q. Kilowatt input.
  - r. Crankcase heater kilowatt.
  - s. Number of fans.
  - t. Condenser fan rpm.
  - u. Condenser fan airflow rate in cfm(L/s).
  - v. Condenser fan motor make, frame size, rpm, and horsepower.
  - w. Condenser fan motor voltage at each connection.
  - x. Condenser fan motor amperage for each phase.
- K. Domestic Water Boilers:
  - 1. Unit Data:
    - a. Unit identification.
    - b. Location.
    - c. Service.
    - d. Make and type.
    - e. Model and serial numbers.
    - f. Fuel type and input in Btuh(kW).
    - g. Number of passes.
    - h. Ignition type.
    - i. Burner-control types.
    - j. Voltage at each connection.
    - k. Amperage for each phase.
- L. Air-to-Air Heat-Recovery Unit Reports:

- 1. Unit Data:
  - a. Unit identification.
  - b. Location.
  - c. Service.
  - d. Make and type.
  - e. Model and serial numbers.
- 2. Motor Data:
  - a. Make and frame type and size.
  - b. Horsepower and rpm.
  - c. Volts, phase, and hertz.
  - d. Full load amperage and service factor.
  - e. Sheave make, size in inches(mm), and bore.
  - f. Sheave dimensions, center-to-center, and amount of adjustments in inches(mm).
- 3. If fans are an integral part of the unit, include the following for each fan:
  - a. Arrangement and size.
  - b. Sheave make, size in inches(mm), and bore.
  - c. Sheave dimensions, center-to-center, and amount of adjustments in inches(mm).
- 4. Test Data (Indicated and Actual Values):
  - a. Total exhaust airflow rate in cfm(L/s).
  - b. Purge exhaust airflow rate in cfm(L/s).
  - c. Outside airflow rate in cfm(L/s).
  - d. Total exhaust fan static pressure in inches wg(Pa).
  - e. Total outside-air fan static pressure in inches wg(Pa).
  - f. Pressure drop on each side of recovery wheel in inches wg(Pa).
  - g. Exhaust air temperature entering in deg F(deg C).
  - h. Exhaust air temperature leaving in deg F(deg C).
  - i. Outside-air temperature entering in deg F(deg C).
  - j. Outside-air temperature leaving in deg F(deg C).
  - k. Calculate sensible and total heat capacity of each airstream in MBh(kW).
- M. Instrument Calibration Reports:
  - 1. Report Data:
    - a. Instrument type and make.
    - b. Serial number.
    - c. Application.
    - d. Dates of use.
    - e. Dates of calibration.

## 3.12 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Engineer.
- B. Engineer shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, proceed as follows:
  - 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
  - If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
- F. Prepare test and inspection reports.

# END OF SECTION 23 0593

# SECTION 23 0700 - HVAC INSULATION

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section includes insulation materials for HVAC systems.
- B. Related Sections:
  - 1. Division 22 Section "Plumbing Insulation."
  - 2. Division 23 Section "Metal Ducts" for duct liners.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated below:
  - 1. Mineral fiber.
  - 2. Flexible elastomeric.
  - 3. Field installed jackets

# 1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program.
- B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

# 1.4 DELIVERY, STORAGE, AND HANDLING

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

### 1.5 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

- B. Coordinate clearance requirements with piping Installer for piping insulation application.
  - 1. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

### 1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

# PART 2 - PRODUCTS

### 2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- E. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
- F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - 1. Provide ASJ or FSK for ductwork applications, as scheduled.
- H. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

# 2.2 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

### 2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
  - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  - 1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
  - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- E. PVC Jacket Adhesive: Compatible with PVC jacket.
  - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

# 2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm(0.009 metric perm) at 43mil(1.09-mm) dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 180 deg F(Minus 29 to plus 82 deg C).
  - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
  - 4. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 3 perms(2 metric perms) at 0.0625-inch(1.6-mm) dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 200 deg F(Minus 29 to plus 93 deg C).
  - 3. Solids Content: 63 percent by volume and 73 percent by weight.
  - 4. Color: White.

## 2.5 SEALANTS

- A. Joint Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Permanently flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 100 to plus 300 deg F(Minus 73 to plus 149 deg C).
  - 4. Color: White or gray.
  - 5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. FSK Jacket Flashing Sealants:
  - 1. Products:
    - a. Childers Products, Division of ITW; CP-76-8.
    - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
    - c. Marathon Industries, Inc.; 405.
    - d. Mon-Eco Industries, Inc.; 44-05.
    - e. Vimasco Corporation; 750.
  - 2. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 3. Fire- and water-resistant, flexible, elastomeric sealant.
  - 4. Service Temperature Range: Minus 40 to plus 250 deg F(Minus 40 to plus 121 deg C).
  - 5. Color: Aluminum.
  - 6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. ASJ Flashing Sealants, and PVC Jacket Flashing Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Fire- and water-resistant, flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 40 to plus 250 deg F(Minus 40 to plus 121 deg C).
  - 4. Color: White.
  - 5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

# 2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factoryapplied jackets are indicated, comply with the following:
  - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
  - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
  - 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
### 2.7 FIELD-APPLIED JACKETS

- Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
  Factory-Fabricated Fitting Covers:
  - a. Same material, finish, and thickness as jacket.
  - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
  - c. Tee covers.
  - d. Flange and union covers.
  - e. End caps.
  - f. Beveled collars.
  - g. Valve covers.
  - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- B. Self-Adhesive Outdoor Jacket: Minimum 40-mil-(1.0-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with aluminum-foil facing.
  - 1. Coordinate color with Architect and Owner.
  - 2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Polyguard; Alumaguard.
    - b. MFM Building Products; Flex Clad 400

# 2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
  - 1. Width: 3 inches(75 mm).
  - 2. Thickness: 11.5 mils(0.29 mm).
  - 3. Adhesion: 90 ounces force/inch(1.0 N/mm) in width.
  - 4. Elongation: 2 percent.
  - 5. Tensile Strength: 40 lbf/inch(7.2 N/mm) in width.
  - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
  - 1. Width: 3 inches(75 mm).
  - 2. Thickness: 6.5 mils(0.16 mm).
  - 3. Adhesion: 90 ounces force/inch(1.0 N/mm) in width.
  - 4. Elongation: 2 percent.
  - 5. Tensile Strength: 40 lbf/inch(7.2 N/mm) in width.
  - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

- 1. Width: 2 inches(50 mm).
- 2. Thickness: 6 mils(0.15 mm).
- 3. Adhesion: 64 ounces force/inch(0.7 N/mm) in width.
- 4. Elongation: 500 percent.
- 5. Tensile Strength: 18 lbf/inch(3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
  - 1. Width: 2 inches(50 mm).
  - 2. Thickness: 3.7 mils(0.093 mm).
  - 3. Adhesion: 100 ounces force/inch(1.1 N/mm) in width.
  - 4. Elongation: 5 percent.
  - 5. Tensile Strength: 34 lbf/inch(6.2 N/mm) in width.

## 2.9 SECUREMENTS

- A. Aluminum Bands: ASTM B 209(ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch(0.51 mm) thick, 1/2 inch(13 mm) or 3/4 inch(19 mm) wide with wing or closed seal.
- B. Insulation Pins and Hangers:
  - 1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
    - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch(0.76 mm) thick by 2 inches(50 mm) square.
    - b. Spindle: Copper- or zinc-coated, low carbon steel, aluminum, or stainless steel; fully annealed, 0.106-inch-(2.6-mm-) diameter shank, length to suit depth of insulation indicated.
    - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
  - 2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
    - a. Baseplate: Perforated, nylon sheet, 0.030 inch(0.76 mm) thick by 1-1/2 inches(38 mm) in diameter.
    - b. Spindle: Nylon, 0.106-inch-(2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches(63 mm).
    - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
  - 3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

- a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch(0.76 mm) thick by 2 inches(50 mm) square.
- b. Spindle: Copper- or zinc-coated, low carbon steel, aluminum, or stainless steel; fully annealed, 0.106-inch-(2.6-mm-) diameter shank, length to suit depth of insulation indicated.
- c. Adhesive-backed base with a peel-off protective cover.
- 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-(0.41-mm-) thick, galvanized-steel, aluminum, or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches(38 mm) in diameter.
  - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-(0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches(38 mm) in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-(19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.062-inch(1.6-mm) soft-annealed, stainless steel.

## 2.10 REMOVABLE INSULATED EQUIPMENT COVER

- A. Provide custom built removable insulating equipment cover for equipment indicated. Covers shall conform to the shape of the equipment.
  - 1. Construct covers using two layers of flexible heat resistant materials with two parallel rows of lock stitching, stuffed with insulation, using belt and loops or velcro like material to hold cover in place.
  - 2. Insulation thickness to provide cold face temperature of 100°F(38°C) at maximum operating temperature.
  - 3. Cover to overlap pipe insulation.

## PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
  - 1. Verify that systems to be insulated have been tested and are free of defects.
  - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

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

### 3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  - 1. Install insulation continuously through hangers and around anchor attachments.
  - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
  - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
  - 1. Draw jacket tight and smooth.
  - Cover circumferential joints with 3-inch-(75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches(100 mm) o.c.

- 3. Overlap jacket longitudinal seams at least 1-1/2 inches(38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches(50 mm) o.c.
  - a. For below ambient services, apply vapor-barrier mastic over staples.
- 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
- 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches(100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. For above ambient services, do not install insulation to the following:
  - 1. Vibration-control devices.
  - 2. Testing agency labels and stamps.
  - 3. Nameplates and data plates.
  - 4. Cleanouts.

## 3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations:
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation at roof structure and seal with joint sealant.
  - 3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 4. Extend jacket of outdoor insulation outside roof flashing at least 2 inches(50 mm) below top of roof flashing.
  - 5. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant.

- 3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
- 4. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches(50 mm).
- 5. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches(50 mm).
  - 1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
  - 1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches(50 mm).
  - 2. Pipe: Install insulation continuously through floor penetrations.
  - 3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."
- G. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
  - 1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
  - 2. Seal longitudinal seams and end joints.

# 3.5 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

- A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 1. Flexible elastomeric pipe insulation only allowed in concealed or mechanical room locations.
- B. Insulation Installation on Pipe Flanges:
  - 1. Install pipe insulation to outer diameter of pipe flange.
  - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
  - 4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

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

## 3.6 MINERAL-FIBER INSULATION INSTALLATION

- A. Insulation Installation on Straight Pipes and Tubes:
  - 1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
  - 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vaporbarrier mastic and joint sealant.
  - 3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches(150 mm) o.c.
  - 4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Fittings and Elbows:
  - 1. Install preformed sections of same material as straight segments of pipe insulation when available.
  - 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- C. Insulation Installation on Valves and Pipe Specialties:
  - 1. Install preformed sections of same material as straight segments of pipe insulation when available.
  - 2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
  - 3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  - 4. Install insulation to flanges as specified for flange insulation application.
- D. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
  - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
  - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitordischarge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

- a. On duct sides with dimensions 18 inches(450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches(75 mm) maximum from insulation end joints, and 16 inches(400 mm) o.c.
- b. On duct sides with dimensions larger than 18 inches(450 mm), place pins 16 inches(400 mm) o.c. each way, and 3 inches(75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
- c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
- d. Do not overcompress insulation during installation.
- e. Impale insulation over pins and attach speed washers.
- f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
- 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches(50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch(13-mm) outward-clinching staples, 1 inch(25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
  - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
  - b. Install vapor stops for ductwork and plenums operating below 50 deg F(10 deg C) at 18-foot(5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches(75 mm).
- 5. Overlap unfaced blankets a minimum of 2 inches(50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches(450 mm) o.c.
- 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- 7. Insulate duct stiffeners, trapeze hanger bars, and duct flanges that protrude beyond insulation surface with 6-inch-(150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches(150 mm) o.c.
- E. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
  - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
  - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitordischarge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - a. On duct sides with dimensions 18 inches(450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches(75 mm) maximum from insulation end joints, and 16 inches(400 mm) o.c.
    - b. On duct sides with dimensions larger than 18 inches(450 mm), space pins 16 inches(400 mm) o.c. each way, and 3 inches(75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

- d. Do not overcompress insulation during installation.
- e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
- 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches(50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch(13-mm) outward-clinching staples, 1 inch(25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
  - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
  - b. Install vapor stops for ductwork and plenums operating below 50 deg F(10 deg C) at 18-foot(5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches(75 mm).
- 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- 6. Insulate duct stiffeners, trapeze hanger bars, and duct flanges that protrude beyond insulation surface with 6-inch-(150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches(150 mm) o.c.

## 3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC fitting jackets are indicated, install with 1-inch(25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.
  - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
  - 2. Fill inside of fitting jackets to prevent collapse of jacket.
- 3.8 FINISHES
  - A. Paintable Jacket Material: Paint jacket with paint system identified in Division 09 painting Sections.

# 3.9 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation: Insulate the following in accordance with insulation schedule:
  - 1. Supply air.
  - 2. Outdoor air.
  - 3. Return air.
  - 4. Relief air.

- 5. Exhaust air.
- 6. Outdoor supply air (Exterior of Building).
- 7. Outdoor return air (Exterior of Building).
- 8. Slot and linear diffuser plenums.
- 9. Commercial, kitchen hood exhaust.
- B. Items Not Insulated:
  - 1. Factory-insulated flexible ducts.
  - 2. Factory-insulated plenums and casings, except as indicated.
  - 3. Flexible connectors.
  - 4. Vibration-control devices.
  - 5. Factory-insulated access panels and doors.
  - 6. Exposed supply and return metal ducts within rooms they are serving except mechanical rooms.
  - 7. Exposed supply metal ducts within rooms they are serving down stream of fan coils and VAV terminal units except mechanical rooms.
  - 8. Volume control balancing damper lever handles.
- C. Definitions:
  - 1. Concealed: Above solid ceiling and not visible from below.
  - 2. Exposed: In rooms with no ceilings or with partial ceilings (i.e. "cloud type ceilings") and visible from below.
  - 3. Finished Spaces: Spaces with room finishes accessible by building occupants.
  - 4. Unfinished Spaces: Spaces with no or limited room finishes accessible by building maintenance and support staff only.

## 3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed outside, relief, supply and return air duct and plenum insulation shall be the following:
  - 1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.
- B. Concealed exhaust-air duct and plenum insulation between isolation damper and penetration of building exterior shall be the following:
  - 1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.
- C. Exposed outside, relief, supply and return air duct insulation within mechanical rooms shall be the following:
  - 1. Mineral-Fiber Board with FSK Jacket (For Rectangular Applications): 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.
  - 2. Mineral-Fiber Duct, Pipe and Tank with FSK Jacket (For Round or Flat Oval Duct Applications): 1-1/2 inches(38 mm) thick.
- D. Exposed exhaust-air duct insulation within mechanical rooms between isolation damper and penetration of building exterior shall be the following:

- 1. Mineral-Fiber Board with FSK Jacket (For Rectangular Applications): 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.
- 2. Mineral-Fiber Duct, Pipe and Tank with FSK Jacket (For Round Duct Applications): 1-1/2 inches(38 mm) thick.
- E. Exposed supply and return air duct insulation exposed in finished spaces shall be the following:
  - 1. Mineral-Fiber Board with ASJ (For Rectangular Applications): 1-1/2 inches(38 mm) thick and 3lb/cu. ft.(48-kg/cu. m) nominal density.
  - 2. Mineral-Fiber Duct, Pipe and Tank with ASJ (For Round or Flat Oval Duct Applications): 1-1/2 inches(38 mm) thick.
- F. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket, board blanket or board; thickness as required to achieve 2-hour fire rating.
- G. Outdoor duct and plenum insulation shall be one of the following:
  - 1. Mineral-Fiber Board: 2 inches(50 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density, with protective field applied jacket.
  - 2. Flexible Elastomeric: 2-1/2 inches(63 mm) thick, with protective field or factory applied jacket.

## 3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain.:
  - 1. All Pipe Sizes Exposed in Mechanical Rooms and Concealed Locations: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
    - b. Flexible Elastomeric: 1 inch(25 mm) thick.
  - 2. All Pipe Sizes Exposed in Finished Spaces: Insulation shall be following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
- B. Refrigerant Suction and Hot-Gas Piping: Insulation shall be one of the following:
  - 1. Mineral-Fiber, Preformed Pipe, Type I: 1 inch(25 mm) thick.
  - 2. Flexible Elastomeric: 1 inch(25 mm) thick.

## 3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping: Insulation shall be one of the following:
  - 1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches(50 mm) thick.
  - 2. Flexible Elastomeric: 2 inches(50 mm) thick.

#### 3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Pipe Fittings with Mineral Fiber Insulation:
  - 1. PVC Fitting Covers: 20 mils(0.6 mm) thick, white.
- 3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE
  - A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
    - 1. If more than one material is listed, selection from materials listed is Contractor's option.
  - B. Ducts and Plenums:
    - Cover mineral fiber insulation with the following:
      - a. Self-adhesive outdoor jacket with aluminum foil facing.
  - C. Piping:

1.

- 1. Cover flexible elastomeric insulation with one of the following:
  - a. Adhere 10 x 10 woven mesh using insulation manufacturer's recommended adhesive and finish with two coats of manufacturer's recommended finish.
  - b. Aluminum, Smooth or Stucco Embossed: 0.024 inch(0.61 mm) thick.
- 2. Cover mineral fiber insulation with one of the following:
  - a. Self-adhesive outdoor jacket with aluminum foil facing.
  - b. Aluminum, Smooth or Stucco Embossed: 0.024 inch(0.61 mm) thick.
- D.

## END OF SECTION 23 0700

#### PERMIT SET

### SECTION 23 0800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This section covers the Contractor's responsibilities for commissioning. Each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.
- B. Comply with Section 01 9113 "General Commissioning Requirements" for overall objectives and requirements.
- 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 HVAC system items to be commissioned are noted below in Par. 3.2.

## 1.2 RELATED REQUIREMENTS

- A. Section 01 9113 General Commissioning Requirements
- B. Section 23 0593 Testing, Adjusting, and Balancing for HVAC
- C. Section 23 0923 Direct-Digital Control System for HVAC
- D. Section 23 0913 Instrumentation and Control Devices for HVAC
- E. Drawings M 601 through M 605 (5 Total) for Sequence of Operations for HVAC Controls
- 1.3 SUBMITTALS Summary
  - A. Details for each item in the summary are shown in the following section.
    1. See Section 01 9113 General Commissioning Requirements, for submittal procedures.
  - B. HVAC Control System Documentation
  - C. Pre-functional Checklists
  - D. Startup Checklists and Plans
  - E. Trend Logs
  - F. Calibration Records
  - G. Certificates of Completion and Readiness

## PERMIT SET

- H. HVAC Control System O&M Manual
- I. Project Record Documents
- J. Training Plan
- K. Training Manuals

## 1.4 SUBMITTALS - Details

- A. HVAC Control System Documentation: Submit detailed sequences of operation, control system drawings, and points list, as specified in Sections 23 09 93 and 23 09 94.
  - 1. Incorporate the sequences of operation information specified in other HVAC specification sections.
  - 2. Incorporate the shop drawing submittal information specified in the HVAC control system section.
  - 3. Inform the Commissioning Authority of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.
- B. Pre-functional Checklists: completed for ALL HVAC equipment, including the BMS.
  - 1. Each checklist line item is to be witnessed, initialed, and dated by the actual witness. Checklists are not complete until all line items are initialed and dated complete without deficiencies.
  - 2. Checklists with incomplete items may be submitted for approval provided the Contractor attests that incomplete items do not preclude the performance of safe and reliable Functional Testing; resubmission of the Checklist is required upon completion of remaining items.
  - 3. Individual Checklists may contain line items that are the responsibility of more than one installer; Contractor shall assign responsibility to appropriate installers or subcontractors, with identification recorded on the form.
  - 4. If any Checklist line item is not relevant, record reasons on the form.
  - 5. Witnessing of Pre-functional testing by the Commissioning Authority is required on this project for:
    - a. TAB for RTU's and DOAS system
    - b. TAB for VRF System and Components
    - c. TAB Ductless Split Systems
    - d. TAB Exhaust Fans
    - e. TAB Electric Wall Heaters
    - f. Gas Fire Places
  - 6. Regardless of these reporting requirements, Contractor is responsible for correct startup and operation.
  - 7. Correct deficiencies and re-inspect or re-test, as applicable. If correction will delay progress, report deficiency to the Commissioning Authority immediately.
  - 8. Submit completed Checklists to Commissioning Authority within two days of completion.
  - 9. Sample Pre-functional Checklists are available for review and will also be available at the pre-bid meeting.
- C. Startup Checklists and Plans: for each item of equipment and system for which the manufacturer provides a startup checklist or plan (not less than 8 weeks prior to startup.)
- D. Trend Logs: As required in "FUNCTIONAL TESTING" section and Functional Performance Tests for approval of Commissioning Authority.
- E. Calibration Records: All calibrations performed by the Contractor.

## PERMIT SET

- F. Certificates of Completion and Readiness:
  - 1. Certification that systems, subsystems, equipment, and associated controls are ready for testing.
  - 2. Certification that installation, prestart, and startup activities have been completed
  - 3. Certification that pipe cleaning, flushing, hydrostatic testing, and chemical treating have been completed.
  - 4. Certification that duct cleaning has been completed.
  - 5. TAB reports. Preliminary reports are acceptable initially a long as they are complete and all tested systems are performing with in the specification requirements.
  - 6. 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.
  - 7. Certification that all controlled components have themselves been successfully Functionally Tested in accordance with the contract documents.
- G. HVAC Control System O&M Manual:
- H. Compile and organize at minimum the following data on the control system in electronic format:
  - 1. Complete as-built record set of control drawings.
  - 2. Complete as-built record sequence of operations for each piece of equipment.
  - 3. Complete as-built points list; in addition to the information on the original points list submittal
  - 4. Control equipment component submittals, parts lists, etc.
  - 5. Warranty requirements.
  - 6. Organize and subdivide the manual with bookmark links 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. Project Record Documents: See Section 01 7800 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.
- J. Training Plan: In addition to requirements specified in Section 01 7900, include:
  - 1. Recommendations of ASHRAE Standard 202.
  - 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.
- K. Training Manuals: See Section 01 7900 for additional requirements.
  - 1. Provide an electronic version of the controls training manuals separately from the O&M manuals.

#### PERMIT SET

## PART 2 - PRODUCTS

## 2.1 TEST EQUIPMENT

- A. Provide all standard testing equipment required to perform startup and initial checkout and required Functional Testing. Unless otherwise noted, such testing equipment remains the property of the respective contractor / provider.
- B. Equipment-Specific Tools: Where 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, the equipment, tools, and instruments shall be provided as part of the work and become the property of Owner.
- C. If not otherwise noted, the following minimum test equipment accuracy requirements apply:
  - 1. Temperature Sensors and Digital Thermometers: Accuracy of  $\pm 0.5F$  and resolution of 0.1F.
  - 2. Pressure Sensors: Accuracy of  $\pm 2.0\%$  of the value measured (not full range of meter).
  - 3. Calibration: According to the manufacturer's recommended intervals and when dropped or damaged; affix calibration tags or keep certificates readily available for inspection.

## PART 3 - EXECUTION

## 3.1 PREPARATION

- A. Cooperate with the Commissioning Authority in development of the Pre-functional Checklists and Functional Test Procedures. This effort includes detailed discussion and clarifications of the Specified Sequences of Operation.
- 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.
  - 1. 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.
- D. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning as required.
- E. Provide Certificates of Completion and Readiness as noted in Submittals section.
- F. Verify the following:
  - 1. Accessibility of equipment and components required for TAB Work.
  - 2. Adequate number and placement of duct balancing dampers to allow proper balancing while minimizing sound levels in occupied spaces.

#### PERMIT SET

- 3. Adequate number and placement of balancing valves to allow proper balancing and recording of water flow.
- 4. Adequate number and placement of test ports and test instrumentation to allow reading and compilation of system and equipment performance data needed to conduct both TAB and commissioning testing. Close test openings with an approved plug
- 5. Air and water flow rates have been specified and compared to central equipment output capacities.
- 3.2 INSPECTING AND TESTING GENERAL
  - A. Submit startup plans, startup reports, and Pre-functional 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. Sensor Tolerances for Standard Applications: Plus/minus the following maximums:

Watthour, Voltage, Amperage	1% of design value
Pressure (Air, Water, Gas)	3% of design value
Differential pressure	sensor readings within 2% of each other
Temperatures (Air dry bulb, water)	0.4F
Wet Bulb and Dew Point temperature	2.0F
Differential temperature (air, water)	sensor readings within 0.2F of each other
Relative Humidity	2%
Barometric Pressure	0.1 inch Hg
Flow Rates (Air)	10% of design value
Flow rates (Water)	4% of design value

- D. Valve/Damper Stroke Setup and Check:
  - 1. For all valve/damper actuator positions checked, verify the actual position against the control system readout with pump/fan in normal operating mode.
    - a. When commanded closed
    - b. When commanded open
    - c. When commanded to 50% open
  - 2. If actual valve/damper position does not reasonably correspond, replace actuator or recommend alternative corrective action.
- E. Correct deficiencies and re-inspect or re-test, as applicable.
- F. When sampling is permitted in the Functional Test List below, the following definitions apply:
  - 1. Identical Units: Defined as units with same application and sequence of operation and minor size or capacity difference.
  - 2. Sampling is not allowed for:
    - a. Major equipment (See respective specification section for identification)
    - b. Life-safety-critical equipment
  - 3. XX = the percent of the group of identical equipment to be included in each sample; defined for specific type of equipment.

#### PERMIT SET

- 4. YY = the percent of the sample that if failed will require another sample to be tested; defined for specific type of equipment.
- 5. Randomly test at least XX percent of each group of identical equipment, but not less than three units. This constitutes the "first sample."
- 6. If YY percent of the units in the first sample fail, test another XX percent of the remaining identical units.
- 7. If YY percent of the units in the second sample fail, test all remaining identical units.
- 8. If frequent failures occur, resulting in more troubleshooting than testing, the Commissioning Authority may stop the testing and require Contractor to perform and document a checkout of the remaining units prior to continuing testing.
- G. Conduct Functional Tests for the following equipment using the test procedures provided by the Commissioning Authority:

Functional Test Equipment & System list				
Equipment Mark	Sampling	Minimum	Retest Cri-	Remarks
	%	No. to test	terion ("YY")	
	("XX")			
RTU's	100%	n/a	n/a	"Major" equipment
DOAS	100%	n/a	n/a	"Major" equipment
VFR System and	100%	n/a	n/a	"Major equipment"
Components				
Exhaust Fans	100%	2	10%	
Electric Wall	100%	1	10%	
Heaters				

When sampling is noted as less than 100%, the actual quantity of tested equipment may not be less than the "Minimum No. to test".

## 3.3 FUNCTIONAL TESTING

- A. Using a skilled technician who is familiar with this building, execute the Functional Testing as required by the Commissioning Authority.
- B. Functional Testing includes demonstration of performance by trend logging of control points monitored by the control system.
  - 1. Trend logging definition and setup must be provided for:
    - a. every digital and analog input and output
    - b. all setpoints
    - c. stored for 12 months using the first in first out (FIFO) storage scheme
  - 2. Trend data must be displayed in charts with multiple variables on each chart, as described in the example trend log description at the end of this section.
    - a. trend up to 20 percent more points than specified, as requested by the Commissioning Authority. (e.g., derived / "Virtual" points, such as energy calculations)
- C. 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.
- D. Demonstrate to the Commissioning Authority during testing of controlled equipment
  - 1. Setpoint changing features and functions.

## PERMIT SET

- 2. Sensor calibrations.
- E. Demonstrate to the Commissioning Authority these Building Management system features:
  - 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.
  - 5. Correct date and time setting in central computer.
  - 6. That field panels read the same time as the central computer
  - 7. Functionality of all field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad
  - 8. Power failure and battery backup and power-up restart functions.
  - 9. Global commands features.
  - 10. Security and access codes.
  - 11. Occupant over-rides (manual, telephone, key, keypad, etc.).
  - 12. O&M schedules and alarms.
  - 13. Occupancy sensors and controls.
  - 14. All control strategies and sequences not tested during controlled equipment testing.

## 3.4 OPERATION AND MAINTENANCE MANUALS

- A. See Section 01 7800 for additional requirements.
- B. Commissioning Authority will add commissioning records to manuals after submission to Owner.

### 3.5 DEMONSTRATION AND TRAINING

- A. See Section 01 7900 for additional requirements.
- B. Demonstrate specified operation and maintenance of HVAC system to Owner' personnel.
- C. These demonstrations are in addition to, and not a substitute for, Pre-functional Checklists and demonstrations to the Commissioning Authority during Functional Testing.

## END OF SECTION 23 0800

#### SECTION 23 0900 – INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Work shall include furnishing all labor, materials, equipment, and service necessary for a complete and operating Building Management System (BMS), utilizing direct digital controls. The BMS shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet. This shall include HVAC control, energy management, alarm monitoring, and all trending, reporting and maintenance management functions related to normal building operations all as indicated.
  - 1. All labor, material, equipment and software not specifically referred to herein or on the plans, required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.
- B. Work shall include but not limited to providing controls and instrumentation in accordance with equipment sequence of operations and their point lists. Point lists shall be a guide to the points required for control system. Final points required shall be determined by sequence of operation requirements.
- C. BACnet Connectoins to all Air Handling Equipment, Individual Ductless Split Systems and Domestic Water Boilers.
- D. Work required in this section shall include providing all control components, control wiring, devices, and services required for the connection and operation of the Air Handling Units external devices, Exhaust Fans, Motorized Dampers, Temperature Sensors for HVAC applications, Domestic Water System, Elevator Sump Pumps and Alarm Monitoring for equipment listed within the specifications and shown on drawings.
- E. Work required in this section shall include providing all control components, control wiring, and services required for the connection of the remaining equipment as indicated on drawings, as specified in various Division 23 sections, and as indicated on controls drawings.
- F. Work required in this section shall include the complete Building Management System (BMS) including all controllers Interoperable LonWorks Controllers (ILC), Interoperable BACnet Controllers (IBC), control devices, control panels, controller programming, controller programming software, controller input/output wiring, power wiring, interlock and safety wiring, graphical user interface, Graphical User Interface (GUI), Graphical Development Tool (GDT), Network Area Controller(s) (NAC), server software, controller software and programming of the NAC and server, development of all graphical screens, setup of schedules, logs and alarms, global server software control applications, system integration and coordination of the NAC and server to the Wide Area Network.
- G. Ethernet LAN wiring, and Ethernet routing devices if applicable. The BMS shall provide a single point Ethernet connection utilizing OBIX TCP/IP to the Owner's WAN.

- H. Work required in this section shall include providing all electrical work required for this section. The system shall include all interconnecting wiring and conduit as required for a fully operational system as specified. Wiring shall be installed as per local codes or Division 26 whichever is more stringent.
  - 1. Power supply wiring and conduit from power source to power connection on DDC controls and DDC control panels.
    - a. Line voltage wiring shall utilize methods and materials complying with the requirements of the Electrical Specifications, local building code, and NEC.
  - 2. Control wiring and conduit between field-installed controls, indicating devices, and control panels.
    - a. Low voltage wiring shall use methods and materials complying with the requirements of the Electrical Specifications, local building code and NEC. Plenum rated cable is acceptable where concealed and accessible.
- I. Work required in this section shall include providing integration between existing mechanical equipment DDC controls not being replaced and the new DDC control system as noted on the drawings.
- J. Work required in this section shall include maintaining the building controls system and its communication/operation with existing and new equipment throughout the course of the project and its Phases.

## 1.2 RELATED SECTIONS

- A. The following Sections contain requirements that relate to this Section:
  - 1. Division 01 Section "Alternates" for requirements of alternates that relate to this Section.
  - 2. Division 23 Section "Common Work Results for HVAC."

# 1.3 WORK BY OTHERS

- A. Setting in place of, meters, water pressure and differential taps, flow switches, thermal wells, dampers, airflow stations, and access doors.
- B. Duct smoke detectors provide under Division 28.

## 1.4 ACTION SUBMITTALS

- A. Refer to Division 1 for submittal administrative requirements and procedures.
- B. Submittal shall consist of:
  - 1. System architecture showing all digital devices, computers and network configuration.
  - 2. Equipment lists of all proposed devices and equipment including data sheets of all products. Provide a PIC statement for each BACnet device and interoperability certification for each LonMark field device provided.

- 3. Valve, damper, and well and tap schedules showing size, configuration, capacity and location of all equipment.
- 4. Data entry forms for initial parameters. Contractor shall provide English listing of all analog points with columnar blanks for high and low warning limits and high and low alarm limits, and a listing of all systems with columnar blanks for beginning and end of occupancy periods; and samples of proposed text for points and messages (for at least two systems of at least 15 points total) including sample 480 character alarm message. All text shall be approved prior to data entry.
- 5. Schematic device wiring and piping interconnection diagrams including panel and device power and sources.
- 6. Software design data including flowchart of a typical DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.
- 7. A complete written Sequence of Operation in suppliers own terminology.

## 1.5 CLOSEOUT SUBMITTALS

- A. Maintenance data for control systems equipment to include in the operation and maintenance manual specified in Division 1. Include the following:
  - 1. Maintenance instructions and spare parts lists for each type of control device.
  - 2. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
  - 3. Calibration records and list of set points.
- B. Project Record Documents: Upon completion of the work, provide a complete set of 'as-built' drawings and application software on USB drive media or compact disk. Drawings shall be provided as AutoCAD<sup>™</sup> or Visio<sup>™</sup> compatible files. Three copies of the 'as-built' drawings shall be provided in addition to the documents on USB drive media or compact disk.

## 1.6 CODES AND APPROVALS

- A. The complete BMS installation shall be in strict compliance to the national, state and local mechanical and electrical codes and the electrical section of these specifications. All devices shall be UL or FM listed and labeled for the specific use, application and environment to which they are applied.
- B. The system shall comply with NFPA 90A Air Conditioning and 90B Warm Air Heating, Air conditioning.
- C. All electronic equipment shall conform to the requirements of FCC regulation Part 15, Section 15 governing radio frequency electromagnetic interference and be so labeled.

## 1.7 WARRANTY

- A. All components, system software, and parts supplied by the BMS contractor shall be guaranteed against defects in materials and workmanship for one year from acceptance date. The BMS contractor at no charge shall furnish labor to repair, reprogram, or replace components during the warranty period. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the Owners request for warranty service within 48 hours during normal business hours.
- B. Warranty Access

1. The Owner shall grant to the controls installer reasonable access to the BMS during the warranty period.

## 1.8 BMS CONTRACTOR QUALIFICATIONS

A. The BMS contractor shall have a local office within a 75 mile(120 Km) radius of the job site, staffed with factory trained engineers fully capable of providing instruction, routine maintenance and 24-hour emergency service on all system components. The BMS contractor shall have a three year experience record in the design and installation of computerized building systems similar in scope and performance to that specified herein, and shall be prepared to provide evidence of this history as condition of acceptance and approval during Submittal.

### 1.9 SOFTWARE LICENSE AGREEMENT

- A. Software licensing for the NAC and server software shall give the Owner the capability to control their system and determine which contractors can bid and engineer their system.
- B. It shall be possible to insure the Owner can prevent unauthorized partners from accessing the system for engineering changes.
- C. Software licensing shall have the freedom to individually manage authorized parties and independent parties.
- D. The software licensing shall have no restrictions on which brand of NAC, server software or System Programming tools can interact with the system. Station Compatibility IN and Station Compatibility OUT must = ALL and Tool Compatibility must = ALL.
- E. The Owner shall accept the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

## 1.10 ADDED POINT AND MEMORY CAPACITY

- A. The BMS software/firmware provided shall have the capacity for an unlimited number of NACs. Systems requiring future upgrades to accomplish this are not acceptable; capacity shall be provided at the time of bid.
- B. Total system point capacity shall have the capacity for an unlimited number of future points. Systems requiring future upgrades to accomplish this are not acceptable; capacity shall be provided at the time of bid.
- C. Supervising software shall allow unlimited expansion. Supervising software that is limited to the number of network area controllers is not acceptable

### 1.11 TESTING AND BALANCING

A. If proper sequencing or system functions cannot be achieved with the controls, as installed, and additional controls are required, the required additional controls shall be added at the expense of the Controls provider.

### 1.12 DELIVERY, STORAGE, AND PROTECTION

- A. Store equipment and materials inside and protected from weather.
- B. Factory-Mounted Components: Arrange for shipping control devices to terminal unit manufacturer for factory mounting on equipment.

#### 1.13 COORDINATION

- A. Coordinate location of exposed control sensors with plans and room details before installation.
- B. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

## PART 2 - PRODUCTS

## 2.1 INSTALLERS

- A. Basis-of-Design: LG Electronics
- B. Subject to compliance with requirements provide installation comparable product by one of the following:
  - 1. Dyken Mcguay/Airtech
  - 2. Johnson Controls Corporate/Hitachi.
  - 3. Train/Mitsubishi.

#### 2.2 GENERAL

- A. The Building Management System (BMS) shall be comprised of a network of interoperable, stand-alone digital controllers, Network Area Controllers, server software server, graphical user interface software, Web Browser Clients, network devices and other devices as specified herein.
- B. Provide the capability to open all control valves in each individual system at one time (I.E. zone, riser) to facilitate water balancing.

### 2.3 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

- A. The requirement of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate SNMP, LonWorks, BACnet IP, BACnet MSTP, Modbus TCP/IP or Modbus RTU communication protocols in one open, interoperable system.
- B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE<sup>™</sup> Standard 135, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet. For each Modbus device supplier must provide a Registry of data points available on the system.
- C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
- D. The supplied system must incorporate the ability to access all data using standard web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
- E. The installed system shall provide secure password access to all features, functions and data contained in the overall BMS. Secure Socket Layer (SSL) encryption shall be an available option for remote access.
- F. The installed system must be totally scalable to allow for future expansion with the addition of controllers and/or input/output devices. It shall not be necessary to remove equipment supplied under this contract to expand the system.
- G. The failure of any single component or network shall not interrupt the control functions of non-affected devices. A single network failure shall only affect shared communications or shared data; individual application controllers and network controllers shall continue normal operation minus only the data from a remote device from the affected network. Automatic default values for all network transported data shall be provided to allow continued operation until the network is restored.
- H. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.
  - 1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
  - 2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

# 2.4 NETWORK AREA CONTROLLER (NAC)

- A. The controls Installer shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices.
- B. The Network Area Controller (NAC) shall provide the interface between the ILC, IBC and the Network server software, and provide global supervisory control functions over the control devices connected to the BMS. It shall be capable of executing application control programs to provide:
  - 1. Calendar functions
  - 2. Scheduling
  - 3. Trending
  - 4. Alarm monitoring and routing
  - 5. Time synchronization
  - 6. Integration of LonWorks controller data, Modbus controller data and BACnet controller data
  - 7. Network Management functions for all LonWorks based devices
- C. The Network Area Controller must provide the following hardware features as a minimum:
  - 1. Two Isolated Ethernet Ports 10/100 Mbps
  - 2. One RS-232 port
  - 3. One RS-485 port
  - 4. One LonWorks Interface Port 78KB FTT-10A
  - 5. Battery Backup
  - 6. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 10 gigabyte storage capacity)
  - 7. The NAC must be capable of operation over a temperature range of 32 to 130 deg F(0 to 55 deg C)
  - 8. The NAC must be capable of withstanding storage temperatures of between 32 to 158 deg F(0 to 70 deg C)
  - 9. The NAC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing
- D. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 10 simultaneous users.
- E. Event Alarm Notification and actions
  - 1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
  - 2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
  - 3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
    - a. To alarm
    - b. Return to normal
    - c. To fault
  - 4. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.

- 5. Provide timed (schedule) routing of alarms by class, object, group, or node.
- 6. Provide alarm generation from binary object "runtime" and for event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- 7. Control equipment and network failures shall be treated as alarms and annunciated.
- 8. Alarms shall be annunciated in any of the following manners as defined by the user:
  - a. Screen message text
  - b. Text or email of the complete alarm message to multiple recipients. Provide the ability to route and send alarms based on:
    - 1) Day of week
    - 2) Time of day
    - 3) Recipient
- 9. Graphic with flashing alarm object(s)
- 10. Printed message, routed directly to a dedicated alarm printer
- 11. The following shall be recorded by the NAC for each alarm (at a minimum):
  - a. Time and date
  - b. Location (building, floor, zone, office number, etc.)
  - c. Equipment (air handler #, access way, etc.)
  - d. Acknowledge time, date, and user who issued acknowledgement.
  - e. Number of occurrences since last acknowledgement.
- 12. Alarm actions may be initiated by user defined programmable objects created for that purpose.
- 13. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
- 14. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.
- 15. Provide a "query" feature to allow review of specific alarms by user defined parameters.
- 16. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
- 17. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.
- F. Data Collection and Storage
  - 1. The NAC shall have the ability to collect data for any object and store this data for future use.
  - 2. The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:
  - 3. Designating the log as interval or deviation.
  - 4. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
  - 5. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
  - 6. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
  - 7. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

- 8. All log data shall be stored in a relational database and the data shall be accessed from a standard Web Browser.
- 9. All log data, when accessed from the Network server software (NS), shall be capable of being manipulated using standard SQL statements.
- 10. All log data shall be available to the user in the following data formats:
  - a. HTML
  - b. XML
  - c. Plain Text
  - d. Comma or tab separated values
- 11. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
- 12. The NAC shall have the ability to archive its log data to Network server software on the network. Provide the ability to configure the following archiving properties, at a minimum:
  - a. Archive on time of day
  - b. Archive on user-defined number of data stores in the log (buffer size)
  - c. Archive when log has reached it's user-defined capacity of data stores
  - d. Provide ability to clear logs once archived
- G. Audit Logs
  - 1. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive the log based on time to the Network server software. For each log entry, provide the following data:
    - a. Time and date
    - b. User ID
    - c. Change or activity: i.e., Change set-point, add or delete objects, commands, etc.
- H. Database Back-Up and Storage
  - 1. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
  - 2. Copies of the current database and, at the most recently saved database shall be stored on the Network server software. The age of the most recently saved database is dependent on the user-defined database save interval.
  - 3. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

# 2.5 INTEROPERABLE LON CONTROLLER (ILC)

- A. Controls shall be microprocessor based Interoperable LonMark<sup>™</sup> or LonWorks Controllers (ILC). Where possible, all Interoperable LonWorks Controllers shall bear the applicable LonMark<sup>™</sup> interoperability logo on each product delivered.
- B. HVAC control shall be accomplished using LonMark<sup>™</sup> based devices where the application has a LonMark profile defined. Where LonMark devices are not available for a particular application, devices

based on LonWorks shall be acceptable. Publicly available specifications for the Applications Programming Interface (API) must be provided to Owner for each LonWorks / LonMark controller defining the programming or setup of each device. The controls Installer shall provide all programming, documentation and programming tools necessary to set up and configure the supplied devices per the specified sequences of operation.

- C. The controls Installer shall run the LonWorks network trunk to the nearest Network Area Controller (NAC). Coordinate locations of the NAC with the LonMark devices to ensure that maximum network wiring distances, as specified by the LonWorks wiring guidelines, are not exceeded. A maximum of 126 devices may occupy any one LonWorks trunk and must be installed using the appropriate trunk termination device. All LonWorks and LonMark devices must be supplied using FTT-10A LonWorks communications transceivers.
- D. The Network Area Controller (NAC), will provide all scheduling, alarming, trending, and network management for the LonMark / LonWorks based devices.
- E. The ILCs shall communicate with the NAC at a baud rate of not less than 78.8K baud. The ILC shall provide LED indication of communication and controller performance to the technician, without cover removal.
- F. All ILCs shall be fully application programmable and shall at all times maintain their LONMARK certification, if so certified. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the ILC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
- G. The controls Installer shall provide documentation for each device, with the following information at a minimum:
  - 1. Network Variable Inputs (nvi's); name and type
  - 2. Network Variable Outputs (nvo's); name and type
  - 3. Network configuration parameters (nci, nco); name and type
- H. It is the responsibility of the controls Installer to ensure that the proper Network Variable Inputs and Outputs (nvi and nvo) are provided in each ILC, as required by the point charts.
- I. The controls Installer of any programmable ILC shall provide one copy of the manufacturer's programming tool, with documentation, to the Owner.

# 2.6 INTEROPERABLE BACnet CONTROLLER (IBC)

- A. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the ANSI/ASHRAE Standard 135-1995. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier must provide a PICS document showing the installed systems compliance level to the ANSI/ASHRAE Standard 135-1995, to Owner.
- B. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps or via the RS485 connection at a baud rate of not less than 38 kbps.

- C. The IBC Sensor shall connect directly to the IBC and shall not utilize any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC Sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC Sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
- D. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the IBC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
- E. The controls Installer shall provide documentation for each device, with the following information at a minimum:
  - 1. BACnet Device; MAC address, name, type and instance number
  - 2. BACnet Objects; name, type and instance number
- F. Ensure that the proper BACnet objects are provided in each IBC, as required by the point charts.

## 2.7 NETWORKS

- A. The Local Area Network (LAN) shall be a 100 Megabits/sec Ethernet network supporting TCP/IP, BACnet IP, Modbus, Java, XML, and HTTP for maximum flexibility for integration of building data with enterprise information systems
- B. Local area network minimum physical and media access requirements:
  - 1. Ethernet; IEEE standard 802.3
  - 2. Cable; 10 Base-T, UTP-8 wire, category 5E or 6
  - 3. Minimum throughput; 10 Mbps, with ability to increase to 100 Mbps

# 2.8 NETWORK ACCESS

A. Owners WAN / LAN Access: Controls Installer must adhere to Owner's policy and requirements to obtain Owner's WAN access.

# 2.9 GRAPHICAL USER INTERFACE (GUI)

A. The graphical component of the BMS is of critical importance and should consider the following descriptions and graphic representations to be the minimum acceptable. Enhanced graphics shall include detailed 2-dimensional building site and floor plan graphics, 3-dimentional equipment graphics with fan, damper and valve animations providing operators an aid to comprehending complex system operation. Every graphic page shall contain a tabular and cascading menu navigational structure, established in an HTML frame based format to allow immediate "one-click" access to other building systems without the need to back up through the navigational tree.

- B. Navigation is done through the use of an HTML-based menu bar. The contents of the menu bar shall be customized to match the specific requirements of each building, while retaining the same general categories for consistency and familiarity.
  - 1. The menu bar shall employ cascading menus. With this navigation concept, the operator shall not be more than two mouse button operations from any view. Some examples of the operator screens follow.
  - 2. Displays shall provide real-time information with visual display of alarm condition by change of color and/or flashing text/color background.
  - 3. Displays can be viewed from a non-proprietary, commercial Web Browser.
  - 4. Points that have been defined as data-writes, either as a digital (on/off) or analog (change value) point type, will be setup such that an operator, by right-clicking the data object or graphic, will be able to command a digital value, or modify an analog value. Operators shall view equipment status from the menu. Menu items shall include headings for major equipment categories such as Air Handling Units, Boiler, Chillers, Zone Control, Lighting, etc. Cascading menus from each major category, shall allow the operator to select a particular piece of equipment; i.e. AHU-1 or Chiller.
  - 5. A maximum of 40 points will be provided in a single status display screen. Points that have been defined as data-writes, either as a digital (on/off) or analog (change value) point type, shall be setup such that an operator, by right-clicking the data object or graphic, shall be able to command a digital value, or modify an analog value.
- C. All Graphics and schedules will reside at the supervisory software level and not at the NAC level to allow for "one password" access to all NACs on the system and global scheduling and trending.

# 2.10 CUSTOM GRAPHICS - REQUIRED

- A. Home Page
  - 1. The building site overview shall provide a "mouse over" function to highlight the floor plan area to be accessed as a navigational aid. Room numbers and/or names will be included at the owner's request. Critical data points, i.e. Outdoor Air Temperature, Outdoor Air Relative Humidity, Hot Water Supply Temperature, Chilled Water Supply Temperature or National Weather Service data will be continuously visible, in real time, within the HTML frame on all screens. Additional points may be added or deleted at the owner's request without cost.
- B. Floor Plans
  - 1. Detailed floor plans shall be created with a vector drawing program accurately depicting the actual building layout to include all rooms, walls, and hallways. All space sensors shall be accurately placed in their actual locations and tagged with their real time space temperature and equipment each is associated with, i.e. 72.5°F/RTU-1, 74.2°/AHU-1, 73.4°/TU-1. Floor plans too large to be practically shown with data points will provide a "mouse over" function to highlight the floor plan area to be accessed. Room numbers and/or names will be included at the owner's request.
- C. Mechanical Systems
  - 1. Detailed graphics for each mechanical system shall include; AHUs, ERUs, CW Piping and Pumps, HW Piping and Pumps, TUs, and EFs as a minimum. Mechanical systems shall include on-screen

access to their respective set-points, trend logs and schedule. All time schedules will be setup as directed by the owner prior to final job turnover.

- 2. Dynamic trends of <u>all</u> data points shall be set up (specification will be followed as to actual number of trend points possible) prior to final job turnover. Each trend will be available directly on screen for quick trend access.
- 3. Data points will be shown for all relevant inputs and outputs and be positioned near the actual device. Analog and digital parameters will be able to be modified directly from the equipment screen.
- D. Terminal Units
  - 1. Terminal units such as cabinet heaters and VAV boxes will depict the actual configuration of the equipment controlled. Actual equipment configurations from manufacturers web sites and/or photos of installed equipment shall be used to ensure graphic depictions are as "near actual" as possible.
- E. Schedules
  - Graphical schedules shall allow the operator to adjust time of day schedules by dragging the On Event slider. An unlimited number of On/Off events shall be allowed for each schedule and schedules can be linked into a Master/Slave scheduling scheme. Schedules shall allow the user to add/edit/delete holiday and special event schedules. Schedules shall be included for each major piece of equipment.
- F. Logging
  - 1. Logs shall be provided for all points defined as requiring collection and archiving of their real-time values. Log data will be provided in HTML, XML, comma- and tab-separated value, and plain-text formats.
    - a. Each of the following of point types shall be continuously trended. The user shall have the ability to select up to 3 points to be displayed on a single trending graph.
      - 1) All Temperatures
      - 2) All Temperature setpoints
      - 3) All Damper Positions
      - 4) All Valve Positions
      - 5) All VFD %
      - 6) All Airflows
      - 7) All Occupancy statuses
      - 8) All Enthalpies
      - 9) All Humidity's
      - 10) All CO2s
  - 2. Setup parameters for each log include; log intervals, number of collection samples, log collection times and archive times, delta logging with change value selection, etc.
  - 3. For every log, the data shall be viewable in both tabular and chart formats.
  - 4. Logs shall be archived to the server software daily at a user specified time of day. Archive data shall be available from the creation time of the log until the last archive time.
  - 5. For every log, the data can be viewed in both tabular and chart formats.

- 6. Logs and archives will be accessible from a Web Browser (Internet Explorer 5.0 or greater).
- 7. Analog Logs: Value Collected every 15 minutes for a log total of 2 days.

## 2.11 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer<sup>™</sup> or Netscape Navigator<sup>™</sup>. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacturer-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BMS, shall not be acceptable.
- C. The Web browser client shall support at a minimum, the following functions:
  - 1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
  - 2. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
  - 3. Storage of the graphical screens shall be in the NAC or server software, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
  - 4. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
  - 5. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    - a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
      - 1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
      - 2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    - b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
    - c. View logs and charts
    - d. View and acknowledge alarms
    - e. Setup and execute SQL queries on log and archive information
  - 6. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

7. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

## 2.12 SERVER SOFTWARE FUNCTIONS AND HARDWARE

- A. The server software shall be provided. The server software shall support all TCP/IP connected to the control system router.
- B. The Network server software shall provide the following functions, at a minimum:
  - 1. Global Data Access: The server software shall provide complete access to distributed data defined anywhere in the system.
  - 2. Distributed Control: The server software shall provide the ability to execute global control strategies based on control and data objects in any control system in the network, local or remote.
  - 3. The server software shall include a master clock service for its subsystems and provide time synchronization for all control systems.
  - 4. The server software shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
  - 5. The server software shall provide scheduling for all control systems and their underlying field control devices.
  - 6. The server software shall provide demand limiting that operates across all control systems. The server software must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
  - 7. The server software shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to control systems. Systems not employing this prioritization shall not be accepted.
  - 8. Each control system supported by the server software shall have the ability to archive its log data, alarm data and database to the Network server software, automatically. Archiving options shall be user-defined including archive time and archive frequency.
  - 9. The server software shall provide central alarm management for all control systems supported by the server software. Alarm management shall include:
    - a. Routing of alarms to display, printer, email and pagers
    - b. View and acknowledge alarms
    - c. Query alarm logs based on user-defined parameters
  - 10. The server software shall provide central management of log data for all control systems supported by the server software. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
    - a. Viewing and printing log data
    - b. Exporting log data to other software applications
    - c. Query log data based on user-defined parameters
- C. Server software Hardware Requirements: supplied by
  - 1. The system integrator will be responsible for loading and testing the software on the PC.
  - 2. The system integrator will coordinate with the owner for testing and authorization.

#### 2.13 SYSTEM PROGRAMMING

- A. The Graphical Development Tool (GDT) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. The programming toolset will be provided to the owner as part of this project. The programming software shall be the same programming toolset as used by the contractor's engineers when programming this project. Access to the programming functions and features of the GDT shall be through password access as assigned by the system administrator.
- B. The GDT shall be available in two versions; a thick-client version licensed to the computing platform on which it is installed and a thin-client version, capable of providing the complete set of engineering functions through a standard Web Browser. Programming and development tools not capable of providing all engineering and application development functions with a standard Web Browser are not acceptable.
- C. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. All graphics must be created with a vector 3-D imaging software package, i.e., Dream Weaver, Illustrator, Cool 3-D or other commercially available graphics package.
- D. Programming Methods
  - 1. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.
  - 2. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
  - 3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
  - 4. All programming shall be done in real-time. Systems requiring the uploading on the owner's IT network, and downloading of database objects shall not be allowed.
  - 5. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

#### 2.14 OBJECT LIBRARIES

- A. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
- B. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
- C. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.
- D. All control objects shall conform to the control objects specified in the BACnet specification.
- E. The library shall include applications or objects for the following functions, at a minimum:
  - Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of onoff events.
  - Calendar Object. The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.
  - 3. Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals
  - 4. Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.
  - 5. Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled unoccupancy time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.
  - 6. Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse
order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.

- F. The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet specification.
  - 1. Analog Input Object Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
  - 2. Analog Output Object Minimum requirement is to comply with the BACnet standard for data sharing.
  - 3. Binary Input Object Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.
  - 4. Binary Output Object Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.
  - 5. PID Control Loop Object Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.
  - 6. Comparison Object Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
  - 7. Math Object Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
  - 8. Custom Programming Objects Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including math and logic functions, string manipulation, and e-mail as a minimum. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for re-use.
  - 9. Interlock Object Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an Air Handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.
  - 10. Temperature Override Object Provide an object whose purpose is to provide the capability of overriding a binary output to an "On" state in the event a user specified high or low limit value is

exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.

- 11. Composite Object Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphical shell of this container.
- G. The object library shall include objects to support the integration of devices connected to the Network Area Controller or server software. At a minimum, provide the following as part of the standard library included with the programming software:
  - LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control
    of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to
    facilitate simple integration of these devices. All network variables defined in the LonMark profile
    shall be supported. Information (type and function) regarding network variables not defined in the
    LonMark profile shall be provided by the device manufacturer.
  - 2. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file and documentation for the device to facilitate device integration.
  - 3. For BACnet devices, provide the following objects at a minimum:
    - a. BACnet Al
    - b. BACnet AO
    - c. BACnet BI
    - d. BACnet BO
    - e. BACnet Device
  - 4. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

# 2.15 OTHER CONTROL SYSTEM HARDWARE

- A. Ethernet Switches
  - 1. 8 Port 10/100 MBPS Switch / Hub
  - 2. Din Rail Mounted
  - 3. LED communication indicators
  - 4. Acceptable Manufacturers
    - a. Contemporary Controls
    - b. INTEL
    - c. Cisco Systems
- B. Temperature Sensors and Transmitters

- 1. General Sensor & Transmitter Requirements
  - a. Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation, and as required to achieve the specified accuracy as specified herein.
  - b. Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.
  - c. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearities of the sensor and bridge and provide a true linear output signal.
  - d. Temperature sensors shall be of the resistance type and shall be 10K or 20K Ohm Thermistor type.
    - 1) Thermistors are acceptable provided the mathematical relationship of a thermistor with respect to resistance and temperature with the thermistor fitting constraints is contained with the controllers operating software and the listed accuracy's can be obtained. Submit proof of the software mathematical equation and thermistor manufacturer fitting constants used in the thermistor mathematical/expressions. Thermistors shall be of the Thermistor (NTC) Type with a minimum of 50 ohm/°C. resistance change versus temperature to insure good resolution and accuracy.
  - e. The following accuracy's are required and include errors associated with the sensor, lead wire and A to D conversion.

<u>nt Type</u>	Accuracy
side Air	+/-3%
led/Hot Water	+/-1%
om Temperature	+/-1%
t Temperature	+/-3%
	<u>nt Type</u> side Air led/Hot Water om Temperature st Temperature

- 2) Sensors Used in Energy Water (BTU) or Process Calculations +/-1%
- 3) Sensors used in energy or process calculations shall be accurate over the process temperature range. Submit a manufacturer's calibration report indicating that the calibration certification is traceable to the National Bureau of Standards (NBS) Calibration Report Nos. 209527/222173.
- 2. Thermowells
  - a. When thermowells are required, the sensor and well shall be supplied as a complete assembly including well head and Greenfield fitting, except where wells are to be installed under separate contract.
  - b. Thermowells shall be pressure rated and constructed in accordance with the system working pressure
  - c. Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
  - d. Thermowells shall be constructed of the following materials:
    - 1) Hot Water; brass.

- 3. Outside Air Sensors
  - a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
  - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
  - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
  - d. Solar load sensors shall be provided in locations shown. The use of a thermistor combined with a solar compensator is acceptable. Provide calibration charts as part of the O&M Manual.
- 4. Duct Type Sensors
  - a. Duct mount sensors shall mount in a hand box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (sealtite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
  - b. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Duct sensors probe shall be constructed of 304 stainless steel.
  - c. For outdoor air duct applications, use a weatherproof mounting box with weatherproof cover and gasket.
- 5. Averaging Duct Type Sensors
  - a. Where called out on the drawings and points lists, provide averaging type duct sensors. Thermistor sensors are acceptable. The sensor shall be multi-point sensitive through the length of the temperature conducting tubing. The thermistors shall be configured in a series / parallel method which creates an end result of total average resistance equal to the same span as a standard thermistor.
  - b. Provide capillary supports at the sides of the duct to support the sensing element.
- C. Relative Humidity Sensors/Transmitters
  - 1. The sensor shall be a solid state, resistance type relative humidity sensor of the Bulk Polymer Design. The sensor element shall be washable and shall resist surface contaminations.
  - 2. Humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2 wire isolated loop powered, 4-20ma, 0-10.0 VDC linear proportional output.
  - 3. The humidity transmitter shall meet the following overall accuracy including lead loss and A to D conversion.
    - a. Room Type Sensor ±2% RH
    - b. Duct Type Sensor ±2% RH
  - 4. Outside air relative humidity sensors shall be installed in a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.
  - 5. Provide a single point humidity calibrator, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
  - 6. Duct type sensing probes shall be constructed of 304 stainless steel and be equipped with a neoprene grommet, bushings and a mounting bracket.

- D. Differential Pressure Transmitters and Accessories
  - 1. General Air and Water Pressure Transmitter Requirements:
    - a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
    - b. Pressure transmitters shall provide the option to transmit a 0 to 5V dc, 0 to 10V dc, or 4 to 20 mA output signal.
    - c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (3 valve manifolds).
    - d. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
    - e. Low air pressure, differential pressure transmitters used for room pressurization control (i.e. laboratories, OR's clean rooms, etc.) shall be equipped with a LED display indicating the transmitter output signal.
    - f. Duct sensing pressure applications where the velocity exceeds 1500 fpm shall utilize a static pressure traverse probes.
  - 2. Low Air Pressure Applications
    - a. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
      - 1) Span: Not greater than two times the design space DP.
      - 2) Accuracy: Plus or minus 0.5% of F.S.
      - 3) Dead Band: Less than 0.3% of output.
      - 4) Repeatability: Within 0.2% of output.
      - 5) Linearity: Plus or minus 0.2% of span.
      - 6) Response: Less than one second for full span input.
      - 7) Temperature Stability: Less than 0.05% output shift per degree change.
    - b. The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
    - c. Acceptable Manufacturers
      - 1) Auto Tran
      - 2) Veris
      - 3) Setra
  - 3. Medium to High Air Pressure Applications
    - a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter except the performance specifications are not as severe. Provide differential pressure transmitters which meet the following performance requirements.
      - 1) Zero & span: (% F.S./Deg. C): .05% including linearity, hysteresis and repeatability
      - 2) Accuracy: 1% F.S. (best straight line)

- 3) Static Pressure Effect: 0.5% F.S.
- 4) Thermal Effects: <±.05% F.S. /Deg. C.
- b. Acceptable manufacturers:
  - 1) Auto Tran
  - 2) Veris
  - 3) Setra
- E. Low Differential, Water Pressure Applications
  - 1. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20mA output in response to variation of flow meter differential pressure or water pressure sensing points.
  - 2. The differential pressure transmitter shall have non-interactive zero and span adjustments adjustable from the outside cover and meet the following performance specifications.
    - a. 0 10 input differential pressure range
    - b. 4 20 mÅ output
    - c. Maintain accuracy up to 20 to 1 ratio turndown
    - d. Reference Accuracy:  $\pm 0.2\%$  of full span
  - 3. Provide a two year warranty for each transmitter. Replace all transmitters found to be defective at no cost to the Owner during the warranty period. Acceptable Manufacturers:
    - a. Tobar
    - b. Veris
    - c. Foxboro
    - d. Omega
    - e. Bailey
    - f. Modus
- F. Medium to High Differential Water Pressure Applications
  - 1. The differential pressure transmitter shall meet the low pressure transmitter specifications except the following:
    - a. Reference Accuracy: ±l% of full span (includes non-linearity, hysteresis, and repeatability)
    - b. Warranty: 1 year.
  - 2. Acceptable Manufacturers:
    - a. Auto Tran
    - b. Veris
    - c. ACI
    - d. Setra
  - 3. Bypass Valve Assembly: Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided

- G. Electronic Damper Actuators
  - 1. General Requirements
    - a. Electronic actuators shall be electric, direct-coupled type capable of being mounted over the shaft of the damper. They shall be UL listed and the manufacturer shall provide a 2 year unconditional warranty from the date of commissioning. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts or 4 VA for VAV actuators. Sound level shall not exceed 45 dB for high torque or 35 dB
    - b. Electronic overload protection shall protect actuator motor from damage. If damper jams actuator shall not burn-out. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.
    - c. Warranty must be two years by manufacturer on actuator as a whole and all components.
    - d. Acceptable manufacturers:
      - 1) Belimo
  - 2. Control Damper Actuators
    - a. OA (outside air), RA (return air), and EA (exhaust air) actuators shall be spring return type for safety functions. Individual battery backup, capacitor return is not acceptable.
    - b. The control circuit shall be fully modulating using 2 10 volt or 4 20 mA signals. Accuracy and repeatability shall be within  $\pm 1/21$  of control signal. A 2 10 v or 4 20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating damper position. Accuracy shall be within  $\pm 2.5\%$ .
    - c. Face and bypass dampers and other control dampers shall be modulating using the same control circuit detailed above but shall not be spring return.
  - 3. Miscellaneous Damper Actuators
    - a. OA combustion and ventilation air intake and EA damper actuators shall be 2 position spring return closed if any water piping, coils or other equipment in the space which the damper serves needs to be protected from freezing. Otherwise drive open, drive closed type 2 position may be used.
    - b. Provide auxiliary switches on damper shaft or blade switch to prove damper has opened on all air handling equipment handling 100% outside air.
  - 4. Combination Smoke and Fire Damper Actuators
    - a. Actuators shall be factory mounted and connected to the damper section and shall conform to UL 555S specifications.
  - 5.
- H. Switches

- 1. Differential Pressure Switches
  - a. All pressure sensing elements shall be corrosion resistant. Pressure sensing elements shall be bourdon tubes, bellows, or diaphragm type. Units shall have tamper-proof adjustable range and differential pressure settings.
  - b. Pressure sensor switch contacts shall be snap action micro-switch type. Sensor assembly shall operate automatically and reset automatically when conditions return to normal. Complete sensor assembly shall be protected against vibration at all critical movement pivots, slides and so forth.
  - c. Differential pressure switches shall be vented to withstand a 50% increase in working pressure without loss of calibration.
  - d. Acceptable Manufacturers: Mercoid, Dryer, McDonnell Miller.
- 2. Electric Low Limit Thermostat (Freeze Stat)
  - a. Duct type, fixed 4 deg F(3 deg C) differential, range 32 to 60 deg F(0 to 15 deg C). Sensing element shall be a 20 feet(6m) long capillary tube responding to the lowest temperature sensed along any 12 inches(305 mm) of bulb length. Switch shall be SPDT 120/240 volts AC, rated for 10 amps at 120 volts full load. Unit shall be manually reset. Provide one low limit thermostat for each 20 sq. ft.(1.86 sq. m) or fraction thereof of coil surface area.
  - b. Provide DPST switches, 1 NO, 1 NC contact.
  - c. Provide manual type low limit thermostat set at 36 deg F(2 deg C) on each air handling unit.
  - d. Provide thermostat override on air handling units for smoke control in area being served.
- 3. Strap-On Aquastat
  - a. UL listed, provided with a suitable removable spring clip for attaching aquastat to pipe and a snap-action SPDT switch. Switch set-point shall be as indicated. Electrical rating shall be 5 amperes, 120 VAC.
- 4. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point.
- I. Flow, Pressure And Electrical Measuring Apparatus
  - 1. Shielded Static Pressure Sensor
    - a. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 3/8" compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.
    - b. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow of 1000 feet/min.(300 m/min) from a radial source.
    - c. The shielded static sensing devices shall be used for both reference and space pressure sensing.
    - d. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.

- 2. Static Pressure Traverse Probe
  - a. Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.
  - b. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
  - c. The duct static traverse probe shall be of 304 stainless steel construction and (except for 3/4" dia. probes with lengths of 24 inches(610 mm) or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure without need for correction factors, with an instrument accuracy of  $\pm 1/2\%$ .
  - d. Acceptable Manufacturers:
    - 1) Auto Tran
    - 2) Veris
    - 3) Setra
- J. Relays And Contactors
  - 1. Relays other than those associated with digital output cards shall be general purpose, enclosed type and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.
  - 2. Solid State Relays (SSR): Input/output isolation shall be greater than IOE<sup>9</sup> ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The contact life shall be 10 x 10 E<sup>6</sup> operations or greater. The ambient temperature range of SSRs shall be -18 to 140 deg F(-28 To+60 deg C). Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.
  - 3. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semipermanent magnets. Contractor shall be double-break-silver-to-silver type protected by arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.
- K. Temperature Control Panels
  - 1. Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. Panels shall conform to NEMA 1 standards, unless otherwise indicated.
  - 2. Control panels shall meet all requirements of UL508A and shall be so certified.
  - 3. All external wiring shall be connected to terminal strips mounted within the panel.
  - 4. Provide engraved phenolic nameplates identifying all devices mounted on the face of control panels and the identification number of the panel.
  - 5. A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.
- L. Any automatic control dampers not specified to be integral with other equipment. Frames shall not be less than 0.094 inch(2.39 mm) galvanized steel. Blades shall not be over 8 inches(200 mm) wide nor less than 0.063 inch(1.52 mm) galvanized steel roll formed. Bearings shall be oilite, ball-bearing or nylon with steel

shafts. Side seals shall be stainless steel of the tight-seal spring type. Dampers and seals shall be suitable for temperature ranges of -40 to 200 deg F(-40 to 93 deg C).

- 1. Individual damper sections shall have a <u>maximum of 16 sq. ft.(1.49 sq. m) of damper surface</u> and each individual damper section to have its own damper operator.
- 2. All proportional control dampers shall be opposed blade type and all two-position dampers shall be parallel blade types.
- 3. Dampers shall be sized to meet ductwork or opening size.
- 4. Dampers shall be ultra-low leakage dampers and the blade edges shall be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 6 CFM per square foot for dampers in excess of sixteen inches square at 1-inch wg(250 Pa).
- M. Thermally Isolated Dampers: Ruskin Model CDT150 or equivalent extruded aluminum thermally isolated control dampers with insulated air-foil shaped blades.
- N. Digital Wall Module: Each wall module shall provide temperature indication to the digital controller.
  - 1. Provide software-limited set point adjustment and occupied/unoccupied override capability where indicated.
  - 2. Module mounted adjustments shall use buttons, no slides or wheels.
- O. Duct smoke detectors shall be furnished and connected to the building fire alarm under Division 28. Contacts shall be provided for the BMS contractor to connect for fan shutdown as specified in the Sequence of Operations.
- P. Carbon Dioxide sensors shall be 0-10 Vdc analog output type, with corrosion free gold-plated Nondispersive Infrared sensing, designed for duct mounting. Sensor shall incorporate internal diagnostics for power, sensor, analog and output checking, and Automatic Background Calibration algorithm for reduced maintenance. Sensor range shall be 0-3000 PPM with +/- 5% and +/- 50 PPM accuracy.
- Q. Outside Air Inlet Airflow Probes:
  - 1. Provide on outside air dampers bead-in-glass thermistor airflow probes capable of continuously measuring the outside air volume.
    - a. The airflow probes shall be factory calibrated to NIST traceable standards and use thermal dispersion technology.
    - b. The airflow traverse probes shall not significantly impact fan performance or contribute to fan generated noise levels.
    - c. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 2% of actual reading.
  - 2. Include matching factory transmitter with an accuracy of ±0.5% of Natural Span and be furnished with a built-in 3-way zeroing valve, user selectable square root function, and integral 3-1/2 digit scalable LCD for display of measured process. The Transmitter shall be housed in a NEMA enclosure with universal 1/8" FPT signal connection ports, and provide 0-5 volt, 0-10 volt, or 4-20ma output signals for use by the building control system.
  - 3. The airflow probes shall be the Ebtron "Gold" Series with class "C" density or equivalent.

PART 3 - EXECUTION

#### 3.1 GENERAL

- A. The BMS shall be designed, installed, and commissioned in a turnkey operational manner; including all labor not noted in Work by Others paragraph of PART I of this section of these specifications, and not noted in other sections of these specifications.
- B. Where control devices are installed on insulated piping or ductwork, provide standoff brackets or thermowells sized to clear insulation thickness. Provide extended sensing elements, actuator linkages, and other accessories as required.

# 3.2 SEQUENCE OF OPERATION

A. Refer to Temperature Control Diagram drawings for sequence of operations.

#### 3.3 INSTALLATION

- A. All controls Installer work shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work.
- B. Line and low voltage electrical connections to control equipment shall be provided by the controls Installer in accordance with these specifications.
- C. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.
- D. All wiring and tubing shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All tubing and wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals. All wiring shall be in accordance with all local and national codes. All line voltage wiring, all wiring exposed, and all wiring in equipment rooms shall be installed in conduit in accordance to the electrical specifications. All electronic wiring shall be #18 AWG minimum THHN and shielded if required, except standard network (Ethernet, LonWorks, etc.) cabling shall be as tested and recommended in lieu of #18 gauge twisted, #22 or #24 gauge is acceptable if used as a part of an engineered structured cabling system. The control manufacturer must submit technical and application documentation demonstrating that this cabling system has been tested and approved for use by the manufacturer of both the control system and the engineered structured cabling system.
  - 1. All wiring in ceiling plenums shall be plenum rated.
- E. This contractor shall provide all sensing, control, and interlock wiring and tubing for the following unless shown or specified elsewhere by others:
  - 1. Boiler interlocks.
  - 2. Condensing units interlocks.
  - 3. Space Temperature sensors.
  - 4. CO2 sensors.

- 5. Connection between occupancy sensors provided by Division 26 and control devices.
- 6. Air to Air Energy Recovery Unit interlocks.
- 7. Smoke detection devices and HVAC equipment shut-down devices.
- F. The controls contractor shall install all software and enter all computer data into the network area controllers, hardware, and related computers including all control programs, initial approved parameters and settings, and graphics.
- G. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install wall-mounting devices in electrical outlet boxes at heights to match lighting controls.
- H. For airflow monitoring devices, perform the following field tests and inspections and prepare test reports:
  - 1. Operational Test: After substantial completion of airflow system, start units to confirm proper operation and readings. Remove and replace malfunctioning units and retest.
  - 2. Test calibration to confirm proper operation and readings.

# 3.4 ACCEPTANCE

- A. The BMS contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operations.
  - 1. Coordinate with other Installers the checkout of each controlled system
- B. The controls Installer shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.
- C. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log above in presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.
- D. System Acceptance: Satisfactory completion is when the controls Installer has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

# 3.5 TRAINING

- A. All training shall be by the BMS Installer and shall utilize operators' manuals and as-built documentation.
- B. The controls Installer shall provide 40 hours of instruction to the Owner's designated personnel on the operation of the BMS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BMS shall include, but not be limited to; device programming software, graphical development software, graphical user interface, the overall operation program, equipment

functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation.

- C. The training shall be in three sessions as follows:
  - 1. Initial Training: One day session (8 hours) after system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the Owners' personnel can start to familiarize themselves with the system before training begins.
  - 2. Follow-Up Training: Two one day sessions (8 hours each) after initial training, and before Formal Acceptance. These sessions will deal with more advanced topics and answer questions.
  - 3. Warranty Follow Up: Two one day sessions (8 hours each) to be scheduled at the request of the Owner during the one year warranty period. These sessions shall cover topics as requested by the owner such as; how to add additional points, create and gather data for trends, graphic screen generation or modification of control routines.
- D. On-Line Service: Include 40 hours of on-line service assistance to include but not be limited to:
  - 1. Programming changes or modifications, including changes and adjustments to control algorithms
  - 2. Graphic changes or modifications as requested by the Owner or consulting engineer.
  - 3. Operator assistance to include short (1 hour or less) refresh training on system diagnostics and operation, i.e., geothermal optimization, scheduling, trending or operator setup.
  - 4. Consulting engineer assistance to include assistance on control system optimization.

# 3.6 POINTS LIST

A. Refer to Temperature Control Diagram drawings for points list. Provide all additional points as required to accomplish all BMS sequences indicated in the drawings and specifications.

# END OF SECTION 23 0900

# **SECTION 23 1123 - FACILITY NATURAL GAS PIPING**

PART 1 - GENERAL

# 1.1 SUMMARY

- A. Section Includes:
  - 1. Pipes, tubes, and fittings.
  - 2. Piping specialties.
  - 3. Piping and tubing joining materials.
  - 4. Valves.
  - 5. Pressure regulators.
  - 6. Mechanical sleeve seals.

#### 1.2 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
  - 1. Piping and Valves: 100 psig(690 kPa) minimum unless otherwise indicated.
- B. Natural-Gas System Pressure within Buildings: 0.5 psig(3.45 kPa) or less but not more than 5 psig(34.5 kPa).

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
  - 1. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
  - 2. Pressure regulators. Indicate pressure ratings and capacities.

# 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- 1.5 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.
- 1.6 DELIVERY, STORAGE, AND HANDLING
  - A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes and valves from direct sunlight.

# 1.7 COORDINATION

A. Coordinate the installation of the natural gas service by the local gas utility.

# PART 2 - PRODUCTS

# 2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
  - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
  - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
  - 4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
    - a. Material Group: 1.1.
    - b. End Connections: Threaded or butt welding to match pipe.
    - c. Face: Lapped.
    - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiralwound metal gaskets.
    - e. Bolts and Nuts: ASME B18.2.1, carbon steel.
- B. PE Pipe: ASTM D 2513, SDR 11.
  - 1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
  - PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

# 2.2 PIPING SPECIALTIES

- A. Appliance Flexible Connectors:
  - 1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
  - 2. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
  - 3. Operating-Pressure Rating: 0.5 psig(3.45 kPa).

- 4. End Fittings: Zinc-coated steel.
- 5. Threaded Ends: Comply with ASME B1.20.1.
- 6. Maximum Length: 72 inches(1830 mm).
- B. Y-Pattern Strainers:
  - 1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
  - 2. End Connections: Threaded ends for NPS 2(DN 50) and smaller; flanged ends for NPS 2-1/2(DN 65) and larger.
  - 3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
  - 4. CWP Rating: 125 psig(862 kPa).
- C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

# 2.3 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

# 2.4 MANUAL GAS SHUTOFF VALVES

- A. See "Manual Gas Shutoff Valve Schedules" below for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2(DN 50) and Smaller: Comply with ASME B16.33.
  - 1. CWP Rating: 125 psig(862 kPa).
  - 2. Threaded Ends: Comply with ASME B1.20.1.
  - 3. Tamperproof Feature: Locking feature for valves indicated in "Manual Gas Shutoff Valve Schedule" Articles.
  - 4. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch(25 mm) and smaller.
  - 5. Service Mark: Valves 1-1/4 inches(32 mm) to NPS 2(DN 50) shall have initials "WOG" permanently marked on valve body.
- C. General Requirements for Metallic Valves, NPS 2-1/2(DN 65) and Larger: Comply with ASME B16.38.
  - 1. CWP Rating: 125 psig(862 kPa).
  - 2. Threaded Ends: Comply with ASME B1.20.1.
  - 3. Flanged Ends: Comply with ASME B16.5.
  - 4. Tamperproof Feature: Locking feature for valves indicated in "Manual Gas Shutoff Valve Schedule" Articles.
  - 5. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

- 1. Body: Bronze, complying with ASTM B 584.
- 2. Ball: Chrome-plated bronze.
- 3. Stem: Bronze; blowout proof.
- 4. Seats: Reinforced TFE; blowout proof.
- 5. Packing: Threaded-body packnut design with adjustable-stem packing.
- 6. Ends: Threaded.
- 7. CWP Rating: 600 psig(4140 kPa).
- 8. Listing: Valves NPS 1(DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
- 9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Bronze Plug Valves: MSS SP-78.
  - 1. Body: Bronze, complying with ASTM B 584.
  - 2. Plug: Bronze.
  - 3. Ends: Threaded or flanged.
  - 4. Operator: Square head or lug type with tamperproof feature where indicated.
  - 5. Pressure Class: 125 psig(862 kPa).
  - 6. Listing: Valves NPS 1(DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - 7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

## 2.5 PRESSURE REGULATORS

- A. General Requirements:
  - 1. Single stage and suitable for natural gas.
  - 2. Steel jacket and corrosion-resistant components.
  - 3. Elevation compensator.
  - 4. End Connections: Threaded for regulators NPS 2(DN 50) and smaller; flanged for regulators NPS 2-1/2(DN 65) and larger.
- B. Line Pressure Regulators: Comply with ANSI Z21.80.
  - 1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
  - 2. Springs: Zinc-plated steel; interchangeable.
  - 3. Diaphragm Plate: Zinc-plated steel.
  - 4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
  - 5. Orifice: Aluminum; interchangeable.
  - 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
  - 7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
  - 8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
  - 9. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
- C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

- 1. Body and Diaphragm Case: Die-cast aluminum.
- 2. Springs: Zinc-plated steel; interchangeable.
- 3. Diaphragm Plate: Zinc-plated steel.
- 4. Seat Disc: Nitrile rubber.
- 5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
- 6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
- 7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

#### 2.6 SLEEVES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

#### 2.7 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
  - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
  - 2. Pressure Plates: Plastic.
  - 3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

#### 2.8 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches(150 mm) wide and 4 mils(0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches(750 mm) deep; colored yellow.

#### PART 3 - EXECUTION

## 3.1 GAS SERVICE

A. Arrange and pay for the installation of the natural gas service piping by the local gas utility. The Contractor shall be responsible for all fees and charges required by the local gas utility for complete installation, inspection, and testing of the system.

## 3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

# 3.3 OUTDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches(900 mm) below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
- C. Install underground, PE, natural-gas piping according to ASTM D 2774.
- D. Install fittings for changes in direction and branch connections.
- E. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch(25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
  - 1. Install steel pipe for sleeves smaller than 6 inches(150 mm) in diameter.
- F. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch(25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- H. Install pressure gage downstream from each service regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

# 3.4 INDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install escutcheons at penetrations of interior walls, ceilings, and floors. Comply with requirements in Division 23 Section "Common Work Results for HVAC."
- K. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- L. Verify final equipment locations for roughing-in.
- M. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- N. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
  - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches(75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- O. Extend relief vent connections for pressure regulators to outdoors and terminate with weatherproof vent cap.
- P. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, and below grade or floors, unless indicated to be exposed to view.
- Q. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
  - 1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
  - 2. Underground Piping Beneath Buildings: Install underground piping beneath buildings encased in a code approved conduit designed to withstand superimposed loads and the same pressure as the pipe.
  - 3. Prohibited Locations:

- a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
- b. Do not install natural-gas piping in solid walls or partitions.
- R. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- S. Connect branch piping from top or side of horizontal piping.
- T. Install unions in pipes NPS 2(DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- U. Do not use natural-gas piping as grounding electrode.
- V. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- W. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."
- X. Install automatic gas shutoff valve furnished by food service equipment supplier.
- Y. Make final connection to gas-fired kitchen equipment furnished by food service equipment supplier.

# 3.5 VALVE INSTALLATION

- A. Install manual gas shutoff valve at each gas-fired piece of equipment.
- B. Install regulators with maintenance access space adequate for servicing and testing.

# 3.6 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
  - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
  - 2. Cut threads full and clean using sharp dies.
  - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
  - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
  - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
  - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
  - 2. Bevel plain ends of steel pipe.

- E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
- F. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
  - 1. Plain-End Pipe and Fittings: Use butt fusion.
  - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

# 3.7 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 1(DN 25) and Smaller: Maximum span, 96 inches(2438 mm); minimum rod size, 3/8 inch(10 mm).
  - 2. NPS 1-1/4(DN 32): Maximum span, 108 inches(2743 mm); minimum rod size, 3/8 inch(10 mm).
  - 3. NPS 1-1/2 and NPS 2(DN 40 and DN 50): Maximum span, 108 inches(2743 mm); minimum rod size, 3/8 inch(10 mm).
  - 4. NPS 2-1/2 to NPS 3-1/2(DN 65 to DN 90): Maximum span, 10 feet(3 m); minimum rod size, 1/2 inch(13 mm).
  - 5. NPS 4(DN 100) and Larger: Maximum span, 10 feet(3 m); minimum rod size, 5/8 inch(15.8 mm).

# 3.8 CONNECTIONS

- A. Install piping adjacent to appliances to allow service and maintenance of appliances.
- B. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches(1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
  - 1. Install pressure regulator at connection to gas-fired appliance and equipment as required to meet maximum gas pressure requirements of that particular device.
- C. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

# 3.9 LABELING AND IDENTIFYING

- A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for above ground piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches(300 mm) below finished grade, except 6 inches(150 mm) below subgrade under pavements and slabs.

## 3.10 PAINTING

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.
- B. Paint exposed, exterior metal piping, valves, and piping specialties, except components with factoryapplied paint or protective coating.
  - 1. Color: Gray.
- C. Paint interior exposed metal piping, valves, and piping specialties in mechanical rooms, except components with factory-applied paint or protective coating.
  - 1. Color: Safety yellow.

# 3.11 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
  - 1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

# 3.12 OUTDOOR PIPING SCHEDULE

- A. Underground natural-gas piping shall be the following:
  - 1. PE pipe and fittings joined by heat fusion; terminated in an accessible location.
- B. Aboveground natural-gas piping shall be the following:
  - 1. For NPS 2(DN 50) and smaller, use steel pipe with malleable-iron fittings and threaded joints.
  - 2. For NPS 2-1/2(DN 65) and larger, use steel pipe with wrought-steel fittings and welded joints.

# 3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG(3.45 kPa) AND LESS THAN 5 PSIG(34.5 kPa)

- A. Aboveground, distribution piping shall be one of the following:
  - 1. For NPS 2(DN 50) and smaller, use steel pipe with malleable-iron fittings and threaded joints.
  - 2. For NPS 2-1/2(DN 65) and larger, use steel pipe with wrought-steel fittings and welded joints.

# 3.14 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

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

# END OF SECTION 23 1123

## **SECTION 23 2300 - REFRIGERANT PIPING**

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.
- B. Related Sections include the following:
  - 1. Division 23 Sections for smaller equipment furnished with refrigerant line sets.

# 1.2 ACTION SUBMITTALS

- A. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
  - 1. Shop Drawing Scale: 1/4 inch equals 1 foot(1:50).
  - 2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

# 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- 1.4 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.
- 1.5 QUALITY ASSURANCE
  - A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
  - B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."
- 1.6 PRODUCT STORAGE AND HANDLING
  - A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

## 1.7 COORDINATION

- A. Coordinate size and location of roof curbs, equipment supports, and roof or wall penetrations.
- B. Coordinate size and location of wall penetrations.

#### PART 2 - PRODUCTS

#### 2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L(ASTM B 88M, Type A or B) or ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
  - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
  - 2. End Connections: Socket ends.
  - 3. Offset Performance: Capable of minimum 3/4-inch(20-mm) misalignment in minimum 7-inch-(180-mm-) long assembly.
  - 4. Pressure Rating: Factory test at minimum 500 psig(3450 kPa).
  - 5. Maximum Operating Temperature: 250 deg F(121 deg C).

# 2.2 VALVES AND SPECIALTIES

- A. Provide the following as required for proper system design and operation:
  - 1. Shut-off and service valves.
  - 2. Check valves.
  - 3. Thermostatic expansion valves.
  - 4. Hot-gas bypass valves.
  - 5. Strainers.
  - 6. Moisture/Liquid Indicators.
  - 7. Replaceable-Core Filter Dryers.

#### 2.3 REFRIGERANTS

A. Provide refrigerant type and amount as required by equipment.

PART 3 - EXECUTION

#### 3.1 PIPING APPLICATIONS

- A. Suction, Hot-Gas, and Liquid Lines: Copper, Type ACR or Type L(B), tubing and wrought-copper fittings with brazed or soldered joints.
  - 1. Provide drawn-temper copper tubing for NPS 1(DN 25) and larger.
  - 2. Provide drawn or annealed temper copper tubing for smaller than NPS 1(DN 25).

# 3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- L. Install refrigerant piping in protective conduit where installed belowground.
- M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- O. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

- P. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."
- Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- R. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- S. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.
- T. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

# 3.3 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
  - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
  - 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
- E. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

#### 3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet(6 m) long.
  - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet(6 m) or longer.
  - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet(6 m) or longer, supported on a trapeze.
  - 4. Spring hangers to support vertical runs.
  - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
  - 1. NPS 1/2(DN 15): Maximum span, 60 inches(1500 mm); minimum rod size, 1/4 inch(6.4 mm).
  - 2. NPS 5/8(DN 18): Maximum span, 60 inches(1500 mm); minimum rod size, 1/4 inch(6.4 mm).
  - 3. NPS 1(DN 25): Maximum span, 72 inches(1800 mm); minimum rod size, 1/4 inch(6.4 mm).
  - 4. NPS 1-1/4(DN 32): Maximum span, 96 inches(2400 mm); minimum rod size, 3/8 inch(9.5 mm).
  - 5. NPS 1-1/2(DN 40): Maximum span, 96 inches(2400 mm); minimum rod size, 3/8 inch(9.5 mm).
  - 6. NPS 2(DN 50): Maximum span, 96 inches(2400 mm); minimum rod size, 3/8 inch(9.5 mm).
  - 7. NPS 2-1/2(DN 65): Maximum span, 108 inches(2700 mm); minimum rod size, 3/8 inch(9.5 mm).
  - 8. NPS 3(DN 80): Maximum span, 10 feet(3 m); minimum rod size, 3/8 inch(9.5 mm).
  - 9. NPS 4(DN 100): Maximum span, 12 feet(3.7 m); minimum rod size, 1/2 inch(13 mm).
- A. Install hangers for steel piping with maximum spacing and minimum rod in accordance Michigan Mechanical Code or MSS SP-69.
- B. Support multifloor vertical runs at least at each floor.

# 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
  - 1. Comply with ASME B31.5, Chapter VI.
  - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
  - 3. Test high- and low-pressure side piping of each system separately.
    - a. Fill system with nitrogen to the required test pressure.
    - b. System shall maintain test pressure at the manifold gage throughout duration of test.
    - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

# 3.6 SYSTEM CHARGING

- A. Charge system using the following procedures:
  - 1. Install core in filter dryers after leak test but before evacuation.
  - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers(67 Pa). If vacuum holds for 12 hours, system is ready for charging.
  - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig(14 kPa).
  - 4. Charge system with a new filter-dryer core in charging line.

# 3.7 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

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

# END OF SECTION 23 2300

## SECTION 23 3113 - METAL DUCTS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes metal ducts for air-distribution systems.
- B. Related Sections include the following:
  - 1. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors, turning vanes, flexible ducts, and flexible connectors.

#### 1.2 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect/Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

#### 1.3 ACTION SUBMITTALS

- A. Product data for the following items:
  - 1. Sealing Materials.
  - 2. Duct Liner.
- B. Duct Leakage Reports: Submit duct leakage test reports. The reports shall be certified proof that the systems have been leak tested, in accordance with this specification section and the referenced standards and are an accurate representation of the system leakage.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- 1.5 QUALITY ASSURANCE
  - A. NFPA Compliance:
    - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
    - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

# 1.6 DELIVERY, STORAGE, AND PROTECTION

- A. Deliver sealant materials to site in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- B. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

#### PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

# 2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90(Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch(6-mm) minimum diameter for lengths 36 inches(900 mm) or less; 3/8-inch(10-mm) minimum diameter for lengths longer than 36 inches(900 mm).
- E. Bird Screen: 1/2 inch mesh, 16 gage galvanized wire.

#### 2.3 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
  - 1. Manufacturers:
    - a. CertainTeed Corp.; Insulation Group.
    - b. Johns Manville International, Inc.
    - c. Knauf Fiber Glass GmbH.
    - d. Owens Corning.

- 2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
  - a. Thickness: 1 inch(25 mm).
  - b. Thermal Conductivity (k-Value): 0.26 at 75 deg F(0.037 at 24 deg C) mean temperature.
  - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
  - d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
    - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - e. Mechanical Fasteners: Galvanized steel suitable for mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
    - 1) Tensile Strength: Indefinitely sustain a 50-lb-(23-kg-) tensile, dead-load test perpendicular to duct wall.
    - 2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch(3 mm) into airstream.

# 2.4 SEALANT MATERIALS

- A. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
  - 1. For indoor applications, use adhesive that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- C. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

# 2.5 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches(100 mm) thick.
  - 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches(100 mm) thick.
- B. Install structural steel members between building structure members as required for upper attachment of hangers and supports. Use members of size and strength required for span and load. The use of joist or truss bridging for hanging and supporting is prohibited.
- C. Hanger Materials: Galvanized sheet steel or threaded steel rod.

- 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
- D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- E. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
  - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

# 2.6 DUCT SUPPORTS ABOVE ROOF

- A. General Requirements for Duct Support Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted ductwork.
- B. High-Type Duct Stands:
  - 1. Description: Assembly of bases, vertical and horizontal members, and duct supports, for roof installation without membrane penetration.
  - 2. Bases: One or more; plastic.
  - 3. Vertical Members: Two or more protective-coated-steel channels.
  - 4. Horizontal Member: Protective-coated-steel channel.

# 2.7 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
  - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
  - 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches(480 mm) and larger and 0.0359 inch(0.9 mm) thick or less, with more than 10 sq. ft.(0.93 sq. m) of nonbraced panel area unless ducts are lined.

# 2.8 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. All sizes shown on the drawings for ducts which require duct liner shall be sizes inside the liner.
- B. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- C. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

- D. Butt transverse joints without gaps and coat joint with adhesive.
- E. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- F. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- G. Secure liner with mechanical fasteners 4 inches(100 mm) from corners and at intervals not exceeding 12 inches(300 mm) transversely; at 3 inches(75 mm) from transverse joints and at intervals not exceeding 18 inches(450 mm) longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
  - 1. Fan discharges.
  - 2. Intervals of lined duct preceding unlined duct.
  - 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.
- I. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

# 2.9 DRYER VENT DUCTWORK

- A. Provide round dryer vent ducts in accordance with SMACNA Standards using snaplock seam ducts with die-formed elbows. Provide cleanouts for ease of duct cleaning.
  - 1. Provide flexible aluminum dryer venting for connection to dryer.
  - 2. For roof outlet installations, provide 18" roof curb and Dryer Jack Model: DJ486U Dryer Vent Cap sized for vent piping.
  - 3. For wall outlet installations, provide plastic wall cap with flapper.

# 2.10 KITCHEN HOOD VENT DUCTWORK

A. Provide ductwork constructed and installed in accordance with SMACNA minimum gauges and requirements. Provide 18 gauge galvanized steel make-up air ductwork and welded 16 gauge galvanized exhaust ductwork as per code requirements and conform to all building requirements and obstructions with all dimensions subject to verification in field. Provide all ductwork with cleanouts every 6'-0" of horizontal run (with pitch as per code) and at changes in direction, access panel, dampers, curbs, flashing, flanges, plenums, supports, insulation, etc. as required by code and to provide a leak proof system.

## 2.11 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

- A. Spiral Duct Manufacturers:
  - 1. Eastern Sheet Metal.
  - 2. SET Duct.

- 3. LaPine Metal Products.
- 4. McGill AirFlow Corporation.
- 5. SEMCO Incorporated.
- 6. Universal Spiral Air.
- B. Round, Longitudinal-Seam Ducts: Fabricate 12 inch (305 mm) and smaller ducts and drops to diffusers of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- C. Round, Spiral Lock-Seam Ducts: Fabricate 13 inch (330 mm) and larger ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Fabricate ducts larger than 72 inches(1830 mm) in diameter with butt-welded longitudinal seams.
- D. Duct Joints:
  - 1. Ducts up to 20 Inches(500 mm) in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
  - 2. Ducts 21 to 72 Inches(535 to 1830 mm) in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
  - 3. Ducts Larger Than 72 Inches(1830 mm) in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
- E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- G. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
  - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
  - 2. Round Mitered Elbows: Welded construction with metal thickness equal to or greater than that of ducts.
  - 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
  - 4. Round Elbows 8 Inches(200 mm) and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30 and 60 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
  - 5. Round Elbows 9 through 14 Inches(225 through 355 mm) in Diameter: Fabricate with gored construction, unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
  - 6. Round Elbows Larger Than 14 Inches(355 mm) in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
  - 7. Die-Formed Elbows for Sizes through 8 Inches(200 mm) in Diameter and All Pressures 0.040 inch(1.0 mm) thick with 2-piece welded construction.
  - 8. Round Gored-Elbow Metal Thickness: Same as metal thickness or greater than that of ducts.
PART 3 - EXECUTION

### 3.1 DUCTWORK CONSTRUCTION

- A. Provide ductwork constructed in accordance with SMACNA Duct Construction Standards but no less than the static pressure classification as indicated below. Fabricate ductwork that will have less leakage than the percentage of system design air flow as indicated below. Test all ductwork for leakage, unless otherwise noted, in accordance with SMACNA HVAC Air Duct Leakage Test Manual and the following.
  - 1. Above Roof Ductwork
    - a. Duct Construction Static Pressure Class: +2-inch wg (250 Pa).
    - b. SMACNA Seal Class: B.
    - c. Percent Leakage of System Design Air Flow: 5 percent.
    - d. Testing Static Pressure: Meeting Michigan Mechanical Code 2015.
  - 2. Constant Volume Supply Air Ductwork (RTU to Diffusers)
    - a. Duct Construction Static Pressure Class: +2-inch wg (500 Pa).
    - b. SMACNA Seal Class: B.
    - c. Percent Leakage of System Design Air Flow: 5 percent.
    - d. Testing Static Pressure: Meeting Michigan Mechanical Code 2015.
  - 3. Constant Volume Supply Air Ductwork (Concealed Ceiling Units to Diffusers)
    - a. Duct Construction Static Pressure Class: +1-inch wg (250 Pa).
    - b. SMACNA Seal Class: C.
    - c. Percent Leakage of System Design Air Flow: 5 percent.
    - d. Testing Static Pressure: Meeting Michigan Mechanical Code 2015.
  - 4. Return Air Ductwork (Inlet grille to RTU or DOAS Units)
    - a. Duct Construction Static Pressure Class: -2-inch wg (500 Pa).
    - b. SMACNA Seal Class: B.
    - c. Percent Leakage of System Design Air Flow: 5 percent.
    - d. Testing Static Pressure: Meeting Michigan Mechanical Code 2015.
  - 5. Return Air Ductwork (Inlet grille to Concealed Ceiling Units)
    - a. Duct Construction Static Pressure Class: -1-inch wg (250 Pa).
    - b. SMACNA Seal Class: C.
    - c. Percent Leakage of System Design Air Flow: 5 percent.
    - d. Testing Static Pressure: Meeting Michigan Mechanical Code 2015.
  - 6. Exhaust Air Ductwork (To roof fans)
    - a. Duct Construction Static Pressure Class: -1-inch wg (250 Pa).
    - b. SMACNA Seal Class: C.
    - c. Percent Leakage of System Design Air Flow: 5 percent.
    - d. Testing Static Pressure: No testing required.
  - 7. Exhaust Air Ductwork (To inline ceiling fans)

- a. Duct Construction Static Pressure Class: -1-inch wg (250 Pa).
- b. SMACNA Seal Class: C.
- c. Percent Leakage of System Design Air Flow: 5 percent.
- d. Testing Static Pressure: No testing required.
- 8. Exhaust Air Ductwork (From ceiling fans and inline ceiling fans to outdoors)
  - a. Duct Construction Static Pressure Class: +1-inch wg (250 Pa).
  - b. SMACNA Seal Class: C.
  - c. Percent Leakage of System Design Air Flow: 5 percent.
  - d. Testing Static Pressure: No testing required.
- 9. Outside Air Ductwork
  - a. Duct Construction Static Pressure Class: -1-inch wg (250 Pa).
  - b. SMACNA Seal Class: C.
  - c. Percent Leakage of System Design Air Flow: 5 percent.
  - d. Testing Static Pressure: No testing required.
- 10. Transfer Air Ductwork
  - a. Duct Construction Static Pressure Class: -1/2-inch wg (125 Pa).
  - b. SMACNA Seal Class: C.
  - c. Percent Leakage of System Design Air Flow: 5 percent.
  - d. Testing Static Pressure: No testing required.

### 3.2 DUCT APPLICATIONS

A. All ducts shall be galvanized steel.

### 3.3 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round and flat-oval ducts in lengths not less than 12 feet(3.7 m) unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches(300 mm), with a minimum of 3 screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch(25 mm), plus allowance for insulation thickness.
- I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- J. Coordinate layout with suspended ceiling, lighting layouts, and similar finished work.
- K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches(38 mm).
- N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Air Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Penetration Firestopping."
- O. Paint interiors of metal ducts, that do not have duct liner, for 24 inches(600 mm) upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.
- P. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system. Install duct mounted control dampers supplied by Temperature Control Installer.
- Q. At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.
- R. Where indicated, install wire mesh bird screen grilles mounted in a removable frame.

# 3.4 DUCT CLEANLINESS REQUIREMENTS

- A. Protect duct interiors from the elements and foreign materials in accordance with the following SMACNA's "Duct Cleanliness for New Construction." Guidelines:
  - 1. Intermediate Level.

# 3.5 SEAM AND JOINT SEALING

- A. All ductwork shall be suitably cleaned and prepared, and sealant applied in strict accordance with manufacturer's instructions. Manufacturer's recommendations for cure time shall be followed before pressure testing is begun. Any additional paint or coatings must conform to manufacturer's specifications. Seal duct seams and joints as follows:
  - 1. Pressure Classifications Greater Than 3 Inches Water Gage: All transverse joints, longitudinal seams, and duct penetrations (SMACNA Seal Class A).
  - 2. Pressure Classification 2 and 3 Inches Water Gage: All transverse joints and longitudinal seams (SMACNA Seal Class B).
  - 3. Pressure Classification Less than 2 Inches Water Gage: Transverse joints only (SMACNA Seal Class C).
- B. Seal ducts and leak test where indicated before external insulation is applied.

# 3.6 HANGING AND SUPPORTING

- A. Support ductwork with support systems indicated in SMACNA "HVAC Duct Construction Standards".
- B. Support horizontal ducts within 24 inches(600 mm) of each elbow and within 48 inches(1200 mm) of each branch intersection.
- C. Support vertical ducts at maximum intervals of 16 feet(5 m) and at each floor.
- D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (prooftest) load.
- E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches(100 mm) thick.
- F. DUCT SUPPORTS ABOVE ROOF INSTALLATION
- G. Install above roof ductwork supports following support, curb, and roofing manufacturer guidelines. Where necessary, patch roofing in accordance with roofing manufacturer requirements.
- H. New Roof Installations:
  - Curb-Mounted-Type Duct Stands: Assemble components or fabricate duct stand and mount on permanent, stationary roof curb. See Section 23 0500 "Common Work Results for HVAC" for curbs.
  - 2. High Type Duct Stand Types: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

# 3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."

- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- C. Louver Plenums: Fabricate of heavy gauge sheet metal material in compliance with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
  - 1. Fabricate with sloped bottom surface.
  - 2. Apply two coats of fire retardant, bitumastic waterproofing material to interior surfaces of bottom and lower half of sides.

# 3.8 FIELD QUALITY CONTROL

- A. Provide duct leakage testing in accordance with SMACNA HVAC Air/Duct Leakage Test Manual and prepare test reports.
- B. Disassemble, reassemble, and seal segments of the systems as required to accommodate leakage testing, and as required for compliance with test requirements.
- C. Conduct tests, in the presence of the Architect/Engineer, at static pressures equal to the maximum design pressure of the system or the section being tested. If pressure classifications are not indicated, test entire system at the maximum system design pressure. Do not pressurize systems above the maximum design operating pressure. Give 3 days' advanced notice for testing.
- D. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.
- E. Seal and leak test externally insulated ducts prior to insulation installation.
- F. Provide Leakage Testing on ductwork located in inaccessible locations (underslab, in walls and chases, etc.) before final covering is performed.

# END OF SECTION 23 3113

# SECTION 23 3300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Manual volume dampers.
  - 2. Control dampers.
  - 3. Fire dampers.
  - 4. Combination fire and smoke dampers.
  - 5. Flange connectors.
  - 6.
  - 7. Turning vanes.
  - 8. Duct-mounted access doors.
  - 9. Flexible connectors.
  - 10. Flexible ducts.
- B. Related Sections:
  - 1. Division 23 Section "Instrumentation and Control for HVAC" for motorized control dampers and damper actuators.
  - 2. Division 23 Section "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
  - 3. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
  - 1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

### 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

# 1.5 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

# PART 2 - PRODUCTS

# 2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G90(Z275).
  - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed applications and No. 4 for exposed applications.
- D. Aluminum Sheets: Comply with ASTM B 209(ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Extruded Aluminum: Comply with ASTM B 221(ASTM B 221M), Alloy 6063, Temper T6.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch(6-mm) minimum diameter for lengths 36 inches(900 mm) or less; 3/8-inch(10-mm) minimum diameter for lengths longer than 36 inches(900 mm).

# 2.2 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Air Balance Inc.; a division of Mestek, Inc.
    - b. American Warming and Ventilating; a division of Mestek, Inc.
    - c. Flexmaster U.S.A., Inc.
    - d. Greenheck.
    - e. McGill AirFlow LLC.
    - f. METALAIRE, Inc.
    - g. Nailor Industries Inc.
    - h. Pottorff.
    - i. Ruskin Company.
    - j. Trox USA Inc.

- k. Vent Products Company, Inc.
- 2. Standard leakage rating, with linkage outside airstream.
- 3. Suitable for horizontal or vertical applications.
- 4. Frames:
  - a. Hat-shaped, galvanized-steel channels, 0.064-inch(1.62-mm) minimum thickness.
  - b. Mitered and welded corners.
  - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
- 5. Blades:
  - a. Multiple or single blade.
  - b. Parallel- or opposed-blade design.
  - c. Stiffen damper blades for stability.
  - d. Galvanized-steel, 0.064 inch(1.62 mm) thick.
- 6. Blade Axles: Galvanized steel.
- 7. Bearings:
  - a. Oil-impregnated bronze or molded synthetic.
  - b. Dampers in ducts with pressure classes of 3-inch wg(750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 8. Tie Bars and Brackets: Galvanized steel.
- B. Damper Hardware:
  - 1. Locking manual quadrant calibrated to show damper position.
  - 2. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-(2.4-mm-) thick zinc-plated steel, and a 3/4-inch(19-mm) hexagon locking nut.
  - 3. Include center hole to suit damper operating-rod size.
  - 4. Include elevated platform for insulated duct mounting.

# 2.3 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Air Balance Inc.; a division of Mestek, Inc.
  - 2. Arrow United Industries; a division of Mestek, Inc.
  - 3. Cesco Products; a division of Mestek, Inc.
  - 4. Greenheck Fan Corporation.
  - 5. McGill AirFlow LLC.
  - 6. METALAIRE, Inc.
  - 7. Nailor Industries Inc.
  - 8. NCA Manufacturing, Inc.
  - 9. Pottorff.
  - 10. Ruskin Company.
  - 11. Vent Products Company, Inc.

- 12. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Type: Static; rated and labeled according to UL 555 by an NRTL.
- C. Fire Rating: 1-1/2 hours.
- D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-(0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
  - 1. Minimum Thickness: 0.052 or 0.138 inch(1.3 or 3.5 mm) thick, as indicated, and of length to suit application.
  - Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.034-inch-(0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-(0.85-mm-) thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Heat-Responsive Device: Replaceable, 165 deg F(74 deg C) rated, fusible links.
- 2.4 COMBINATION FIRE AND SMOKE DAMPERS
  - A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1. Air Balance Inc.; a division of Mestek, Inc.
    - 2. Cesco Products; a division of Mestek, Inc.
    - 3. Greenheck Fan Corporation.
    - 4. Nailor Industries Inc.
    - 5. Pottorff.
    - 6. Ruskin Company.
  - B. Type: Static; rated and labeled according to UL 555 and UL 555S by an NRTL.
  - C. Fire Rating: 1-1/2 hours.
  - D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch-(0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
  - E. Heat-Responsive Device: Replaceable, 165 deg F(74 deg C) rated, fusible links.
  - F. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-(0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-(0.85-mm-) thick, galvanized-steel blade connectors.

- G. Leakage: Class II.
- H. Rated pressure and velocity to exceed design airflow conditions.
- I. Mounting Sleeve: Factory-installed, 0.052-inch-(1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.
- J. Damper Motors: Two-position action.
- K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
  - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
  - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
  - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf(17 N x m) and breakaway torque rating of 150 in. x lbf(17 N x m).
  - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F(minus 40 deg C).
  - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft.(2.3 sq. m), size motor for running torque rating of 150 in. x lbf(17 N x m) and breakaway torque rating of 300 in. x lbf(34 N x m).
  - 7. Electrical Connection: 115 V, single phase, 60 Hz.
- L. Accessories:
  - 1. Auxiliary switches for signaling fan control or position indication.
  - 1. Test and reset switches, damper mounted.

# 2.5 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ductmate Industries, Inc.
  - 2. Nexus PDQ; Division of Shilco Holdings Inc.
  - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.
- E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90(Z275), galvanized sheet steel.

F. Connection Sizes: Match connecting ductwork unless otherwise indicated.

### 2.6 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ductmate Industries, Inc.
  - 2. Duro Dyne Inc.
  - 3. METALAIRE, Inc.
  - 4. SEMCO Incorporated.
  - 5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall for ducts up to 48 inches(1200 mm) wide and double wall for larger dimensions.

### 2.7 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. American Warming and Ventilating; a division of Mestek, Inc.
  - 2. Cesco Products; a division of Mestek, Inc.
  - 3. Ductmate Industries, Inc.
  - 4. Flexmaster U.S.A., Inc.
  - 5. Greenheck Fan Corporation.
  - 6. McGill AirFlow LLC.
  - 7. Nailor Industries Inc.
  - 8. Pottorff.
  - 9. Ruskin.
  - 10. Ventfabrics, Inc.
  - 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
- C. Rectangular Ductwork Applications:
  - 1. Door:
    - a. Double wall, rectangular.
    - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    - c. Hinges and Latches: 1-by-1-inch(25-by-25-mm) butt or piano hinge and cam latches.

- d. Fabricate doors airtight and suitable for duct pressure class.
- 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- 3. Number of Hinges and Locks:
  - a. Access Doors Less Than 12 Inches(300 mm) Square: No hinges and two sash locks.
  - b. Access Doors up to 18 Inches(460 mm) Square: Two hinges and two sash locks.
  - c. Access Doors up to 24 by 24 Inches(600 by 60 mm): Three hinges and two compression latches with outside and inside handles.
- D. Round Ductwork Applications:
  - 1. Sandwich Type for Uninsulated Ductwork: Oval shaped inner and outer plates connected by bolt fasteners and compression springs with hand knobs for compression fit in duct sidewall.
    - a. Provide doors with insulated inner plate for installation in pre-insulated double wall ductwork.
  - 2. Rectangular Type for Insulated Ductwork: Same as specified for rectangular ductwork application with field or factory installed rectangular tap.
- E. Pressure Relief Access Door:
  - 1. Door and Frame Material: Galvanized sheet steel.
  - 2. Door: Single wall for uninsulated duct applications and double wall with insulation fill for insulated duct applications with metal thickness applicable for duct pressure class.
  - 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
  - 4. Doors close when pressures are within set-point range.
  - 5. Hinge: Continuous piano.
  - 6. Latches: Cam.
  - 7. Seal: Neoprene or foam rubber.
  - 8. Insulation Fill: 1-inch-(25-mm-) thick, fibrous-glass or polystyrene-foam board.
  - 9. Factory set at pressure settings indicated below:
    - a. Spring clips rated at 3-inch wg (750 Pa) negative and 5-inch wg(1250 Pa) positive for VAV applications.
    - b. Spring clips rated at 2-inch wg (500 Pa) negative and 3-inch wg (750 Pa) positive for constant volume systems.

# 2.8 FLEXIBLE CONNECTORS

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

- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches(89 mm) wide attached to 2 strips of 2-3/4-inch-(70-mm-) wide, 0.028-inch-(0.7-mm-) thick, galvanized sheet steel or 0.032-inch-(0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd.(880 g/sq. m).
  - 2. Tensile Strength: 480 lbf/inch(84 N/mm) in the warp and 360 lbf/inch(63 N/mm) in the filling.
  - 3. Service Temperature: Minus 40 to plus 200 deg F(Minus 40 to plus 93 deg C).
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
  - 1. Minimum Weight: 24 oz./sq. yd.(810 g/sq. m).
  - 2. Tensile Strength: 530 lbf/inch(93 N/mm) in the warp and 440 lbf/inch(77 N/mm) in the filling.
  - 3. Service Temperature: Minus 50 to plus 250 deg F(Minus 45 to plus 121 deg C).

### 2.9 FLEXIBLE DUCTS

- A. Insulated, Flexible Duct (Type F-1): UL 181, Class 1, acoustically rated, woven fiberglass fabric with flame resistant coated core supported by helically wound, spring-steel wire; fibrous-glass insulation (R-4.2); bidirectional reinforced metallized vapor-barrier film.
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Themaflex Model M-KC or comparable product by the following:
    - a. Flexmaster U.S.A., Inc.
  - 2. Positive Pressure Rating: 16-inch wg(4000 Pa) positive for sizes 4 to 10 Inches(100 to 250 mm), 10-inch wg(2500 Pa) positive for sizes 12 to 16 Inches(300 to 400 mm).
  - 3. Negative Pressure Rating: 2.0-inch wg(500 Pa) negative for sizes 4 to 16 Inches(100 to 400 mm).
  - 4. Maximum Air Velocity: 6000 fpm(30 m/s).
  - 5. Temperature Range: Minus 20 to plus 250 deg F(Minus 29 to plus 1221 deg C).
  - 6. Insulation R-value: R-4.2
- B. Flexible Duct Connectors:
  - 1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or nylon strap in sizes 3 through 18 inches(75 through 460 mm), to suit duct size.

# PART 3 - EXECUTION

# 3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

- B. Install duct accessories of galvanized-steel materials in galvanized-steel ducts.
- C. Install turning vanes in all square or rectangular 90 degree elbows.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
  - 1. Install steel volume dampers in steel ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install fire and fire/smoke dampers according to UL listing.
- G. Connect ducts to duct silencers rigidly.
  - 1. Do not locate duct silencers within one duct diameter from fan discharge/intake openings, elbows, or takeoffs.
  - 2. When elbows precede duct silencer by less than 3 duct widths (as measured in the elbow plane), splitters should be parallel to the plane of the elbow turn.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  - 1. At outdoor-air intakes and mixed-air plenums.
  - 2. Downstream from control dampers, backdraft dampers, and equipment.
  - 3. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
    - a. For fire or smoke dampers located in ducts with no other air path between AHU outlet and damper, install pressure relief access doors upstream of fire or smoke dampers.
    - b. For fire or smoke dampers located in ducts with high velocity and no other air path between AHU outlet and damper, install pressure relief access doors upstream and down stream of fire or smoke dampers.
    - c. For fire or smoke dampers located in ducts with high velocity and other air paths between AHU outlet and damper, install pressure relief access doors down stream of fire or smoke dampers.
  - 4. At each change in direction and at maximum 50-foot(15-m) spacing.
  - 5. Upstream or downstream from duct silencers.
  - 6. Upstream and downstream of duct mounted airflow monitor devices.
  - 7. At duct mounted smoke detectors.
  - 8. Control devices requiring inspection.
  - 9. Elsewhere as indicated.
- I. Access Door Minimum Sizes:
  - 1. Two-Hand or Inspection Access: 12 by 12 inches(300 by 300 mm).

- 2. Head and Shoulders Access: 20 by 16 inches(500 by 400 mm).
- 3. For ducts less than 12 by 12 inches(300 by 300 mm), install largest size access door that fits duct size from manufacturer's standard sizes.
- J. Install flexible connectors to connect ducts to equipment.
- K. Install flexible ducts as follows:
  - 1. Install flexible ducts at accessible concealed locations only.
  - Connect terminal units to high velocity supply ducts with maximum 18-inch(450-mm) lengths of flexible duct Type F-1, clamped or strapped in place. Flexible ducts are for alignment purposes only. Do not use flexible ducts to change directions.
  - Connect diffusers to ducts directly or with maximum 60-inch(1500-mm) lengths of flexible duct Type F-1, clamped or strapped in place. Flexible ducts are for alignment purposes only. Do not use flexible ducts to change directions.

# 3.2 FIELD QUALITY CONTROL

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

# END OF SECTION 23 3300

## SECTION 23 3423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Centrifugal roof ventilators.
  - 2. Ceiling-mounting ventilators.
  - 3. In-line centrifugal fans.

### 1.2 PERFORMANCE REQUIREMENTS

A. Operating Limits: Classify according to AMCA 99.

### 1.3 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
  - 1. Certified fan performance curves with system operating conditions indicated.
  - 2. Certified fan sound-power ratings.
  - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - 4. Material thickness and finishes.
  - 5. Dampers, including housings, linkages, and operators.
  - 6. Roof curbs.

# 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- 1.5 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.
- 1.6 QUALITY ASSURANCE
  - A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

### 1.8 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof and wall penetrations.

### PART 2 - PRODUCTS

### 2.1 CENTRIFUGAL ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Greenheck.
  - 2. Loren Cook Company.
  - 3. Penn-Barry.
- B. Description: Belt- or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
- D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- E. Drive Assembly: Resiliently mounted to housing, with the following features:
  - 1. Motor: ECM with integral speed control.
  - 2. Fan motor isolated from exhaust airstream.
- F. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
  - 1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
  - 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
  - 4. Fan motor isolated from exhaust airstream.

- G. Accessories:
  - 1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
  - 2. Bird Screens: Removable, 1/2-inch(13-mm) mesh, aluminum or brass wire.
  - 3. Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
  - 4. Motorized Dampers: Thermally isolated dampers mounted in curb base with electric actuator and auxiliary end switch; wired to close when fan stops.
- H. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-(40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch(40-mm) wood nailer. Size as required to suit roof opening and fan base. Curb height to be minimum 18" from roof.
  - 1. Configuration: Self-flashing with mounting flange.
  - 2. Overall Height: As scheduled.
  - 3. Pitch Mounting: Manufacture curb for roof slope.

### 2.2 CEILING-MOUNTING VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Greenheck.
  - 2. Loren Cook Company.
  - 3. Penn Barry.
- B. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.
- C. Housing: Steel, lined with acoustical insulation.
- D. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- E. Grille: Louvered grille with flange on intake, attached to fan housing.
- F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plugin.
- G. Accessories:
  - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
  - 2. Isolation: Rubber-in-shear vibration isolators.
  - 3. Manufacturer's standard roof jack or wall cap, and transition fittings.
  - 4. Back Draft Damper

# 2.3 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Greenheck.
  - 2. Loren Cook Company.

- 3. Penn -Barry.
- B. Description: In-line, direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
- C. Housing: Square galvanized steel or aluminum with inlet and outlet flanges, removable access panels, and support brackets adaptable to floor, side wall, or ceiling mounting.
- D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Fan Wheels: Aluminum, welded to aluminum hub.
- F. Accessories:
  - 1. Back Draft damper
  - 2. Vibration Isolators:
    - a. Type: Elastomeric hangers.
    - b. Static Deflection: 1 inch(25 mm).

### 2.4 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

#### 2.5 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

#### PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Secure roof-mounted ventilators to roof curbs with cadmium-plated hardware.
- C. Support suspended ceiling mounted units from structure using threaded steel rods and vibration isolators.
- D. Support suspended high volume low speed fans from structure using structural steel framing. Install factory furnished field installed control components.

- 1. In buildings equipped with sprinklers, including ESFR sprinklers, fan installation shall comply with NFPA and manufacturers requirements.
- 2. All HVLS fans shall be interlocked to shut down immediately upon receiving a water flow signal from the fire alarm system in accordance with the requirements of NFPA 72—National Fire Alarm and Signaling Code.
- E. Install units with clearances for service and maintenance.
- F. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

### 3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. For ceiling mounted fans, make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

# 3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Verify that shipping, blocking, and bracing are removed.
  - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - 3. Verify that cleaning and adjusting are complete.
  - 4. For belt drive units, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  - 5. For direct drive units, Verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
  - 6. Adjust damper linkages for proper damper operation.
  - 7. Verify lubrication for bearings and other moving parts.
  - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  - 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
  - 10. Shut unit down and reconnect automatic temperature-control operators.
  - 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

# 3.4 ADJUSTING

A. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

### 3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fans. Refer to Division 01 Section "Demonstration and Training."
  - 1. Provide video recording of training sessions that details operating and maintenance procedures of equipment.

### END OF SECTION 23 3423

# SECTION 23 3713 - DIFFUSERS, REGISTERS, AND GRILLES

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section includes louvers, and diffusers, registers, and grilles.
- B. Related Sections:
  - 1. Division 23 Section "Air Duct Accessories" for volume-control dampers not integral to diffusers, registers, and grilles.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
  - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
  - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples for Initial Selection: For louvers with factory-applied color finishes.

# PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
  - 1. Grilles, Registers and Diffusers:
    - a. Krueger.
    - b. Price.
    - c. Titus.
  - 2. Louver Manufacturers:
    - a. Air Balance Inc.
    - b. All-Lite Architectural Products.
    - c. American Warming and Ventilating.
    - d. Arrow United Industries.
    - e. Construction Specialties.
    - f. Dowco Products.
    - g. Greenheck Fan Corp.
    - h. Industrial Louvers.

- i. Louvers and Dampers.
- j. NCA Manufacturing.
- k. Ruskin Company.

# 2.2 DIFFUSERS

- A. General: Provide manufacturer's standard diffusers where shown; of size, shape, capacity and type as listed on diffuser schedule, with accessories and finishes as indicated.
  - 1. Diffuser Faces:
    - a. Square: Square housing; core of square concentric louvers; square or round duct connection.
    - b. Rectangular: Rectangular housing; core of rectangular concentric louvers; square or round duct connection.
    - c. Panel: Square or rectangular housing extended to form panel to fit in ceiling system module; core of square or rectangular concentric louvers; square or round duct connection.
    - d. Slot: Aluminum continuous single or multiple slot with plenum and extended frame to fit in ceiling system module. Provide full coverage 1/2-inch thick coated erosion resistant insulation liner inside plenum.
  - 2. Diffuser Mountings
    - a. Surface: Diffuser housing at duct, wall or ceiling surface with gasketed perimeter flange.
    - b. Lay-In: Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.

# 2.3 GRILLES AND REGISTERS

- A. General: Provide manufacturer's standard grilles and registers where shown; of size, shape, capacity and type as listed on schedule, with accessories and finishes as indicated.
  - 1. Register and Grille Materials:
    - a. Steel Construction: Manufacturer's standard stamped sheet steel frame and adjustable blades.
    - b. Aluminum Construction: Manufacturer's standard extruded aluminum frame and adjustable blades.

# 2.4 SECURITY INLETS AND OUTLETS

- A. General: Provide manufacturer's security inlets and outlets where shown; of size, shape, capacity and type as listed on schedule, with accessories and finishes as indicated.
  - 1. Materials:
    - a. Steel Construction: Manufacturer's standard steel face, frame and structure attachments.

- 2.5 LOUVERS
  - A. Horizontal, Drainable-Blade Louvers:
    - 1. Louver Depth: 6 inches (150 mm).
    - 2. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm).
    - 3. Mullion Type: Exposed.
    - 4. Louver Performance Ratings:
      - a. Free Area: Not less than 8.3 sq. ft. (0.77 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
      - b. Point of Beginning Water Penetration: Not less than 950 fpm (4.8 m/s).
    - 5. Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 550-fpm (2.8-m/s) free-area intake velocity.
    - 6. Screen: Aluminum 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.60-mm) wire bird screen on interior face.
    - 7. Fabrication: Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
    - 8.
    - 9. Finish: As selected by Architect using an RAL designation.

# 2.6 SOURCE QUALITY CONTROL

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

# PART 3 - EXECUTION

# 3.1 DIFFUSER, REGISTER, AND GRILLE INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
  - 1. Locate slot diffusers as indicated on general construction drawings. Locate units along one side of acoustical ceiling modules.
- C. Install diffusers, registers, and grilles with airtight connections to ducts.
- D. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

# 3.2 LOUVER INSTALLATION

- A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Protect unpainted galvanized and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
- F. Restore louvers damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

# END OF SECTION 23 3713

# **SECTION 23 3723 - HVAC GRAVITY VENTILATORS**

PART 1 - GENERAL

- 1.1 SUMMARY
  - A. This Section includes the following types of roof-mounting intake and relief ventilators:
    - 1. Roof hoods.
  - B. Related Sections include the following:
    - 1. Division 23 Section "HVAC Power Ventilators" for roof-mounting exhaust fans.

### 1.2 ACTION SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

# 2.2 MATERIALS

- A. Aluminum Extrusions: ASTM B 221(ASTM B 221M), Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: ASTM B 209(ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90(Z275) zinc coating, mill phosphatized.
- D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.
  - 1. Use types and sizes to suit unit installation conditions.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

### 2.3 ROOF HOODS

- A. Manufacturers:
  - 1. Greenheck.
  - 2. Loren Cook Company.
  - 3. Penn Ventilation.
  - 4. Ruskin.
- B. Factory fabricate according to SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figures 5-6 and 5-7.
- C. Materials: Galvanized-steel sheet, minimum 0.064-inch-(1.62-mm-) thick base and 0.040-inch-(1.0-mm-) thick hood; suitably reinforced.
- D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-(40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch(40-mm) wood nailer. Size as required to fit roof opening and ventilator base. Provide with level top and bottom to match roof slope.
  - 1. Configuration: Self-flashing with mounting flange.
  - 2. Overall Height: Refer to drawing detail.
- E. Bird Screening: Galvanized-steel, 1/2-inch-(12.7-mm-) square mesh, 0.041-inch(1.04-mm) wire.
- F. Insulation: Insulate inside bottom of ventilator roof.
- G. Filters: 2 inch washable within intake openings.

# PART 3 - EXECUTION

# 3.1 INSTALLATION

- A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure gravity ventilators to roof curbs with cadmium-plated hardware. Use concealed anchorages where possible.
  - 1. Due to large size of hoods, provide additional anchorages as detailed.
- C. Install gravity ventilators with clearances for service and maintenance.
- D. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 Section "Joint Sealants" for sealants applied during installation.
- E. Label gravity ventilators according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."
- F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

G. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories.

END OF SECTION 23 3723

# SECTION 23 7200 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes packaged energy recovery units.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Wiring Diagrams: For power, signal, and control wiring.
  - 3. Sequence of operations of factory controls.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- 1.4 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

### 1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: One set of each type of filter specified.
  - 2. Fan Belts: One set of belts for each belt-driven device.

#### 1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ARI Compliance:

- 1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
- C. ASHRAE Compliance:
  - 1. Applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 "Construction and Startup."
  - 2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

### 1.7 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

### 1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Energy Recovery Wheel: 5 years.

# PART 2 - PRODUCTS

# 2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings LG Electronics or as listed below:
  - 1. Aaon
  - 2. Daikin/Mcquay
  - 3. JCI/York
  - 4. LG Electronics
  - 5. Trane
  - 6. Valent

# 2.2 PACKAGED ENERGY RECOVERY UNITS

- A. Casing Construction:
  - 1. Unit shall be constructed for outdoor installation on a roof curb.
  - 2. Base:
    - a. Base rails shall be constructed of a minimum of 10 gage galvanized steel with 16 gage integral floor pan.

- b. Base shall have a minimum 4" overhang over the top of a roof curb to prevent water infiltration.
- c. All floor seams shall have a raised rib joint.
- d. There shall be no penetrations through the floor of the unit within the perimeter of the curb except for duct openings and utility chases.
- e. Penetrations through the side wall.
- f. Roof curb shall be provided with 2" of vibrations isolation and fully insulated.
- g. Options:
  - 1) Base pan shall be insulated with <sup>1</sup>/<sub>2</sub>" closed-cell neoprene liner.
- 3. Panels:
  - a. Casing shall be constructed with minimum 2-inch, foam-injected, double-wall panels.
  - b. Individual panels shall be constructed so that they are thermally broken (there shall be no metal-to-metal contact between the interior and exterior sheet metal of each panel).
  - c. Interior side of panel shall be 22 gage G-90 galvanized steel.
  - d. Exterior side of panel shall be 22 gage painted steel rated for 1000 hours in accordance with ASTM B117 and ASTM D1654.
  - e. Insulation:
    - 1) Insulation shall be 2 lb/ft3 foam insulation with an average R-value of 6 per inch.
    - 2) Insulation water absorption must be no more that 0.038 lb/ft per ASTM D 2842 and show "no growth" per ASTM G21 biocide testing.
    - 3) No insulation shall be exposed to the air stream.
    - 4) Fiberglass insulation is not acceptable due to possibility of sloughing and moisture retention.
- 4. Access Doors:
  - a. Access doors shall be provided for access to all components requiring regular maintenance or inspection.
  - b. Access doors shall have a minimum of two quarter-turn compression latches with adjustable catches.
  - c. Access door construction shall be identical to unit casing.
  - d. Interior side of access doors shall be 22 gage G-90 galvanized steel.
  - e. Exterior side of panel shall be 22 gage painted steel rated for 1000 hours in accordance with ASTM B117 and ASTM D1654.
  - f. Access doors shall be sealed with a full-perimeter gasket constructed of Mylar-encased lowdensity foam.
  - g. Insulation:
    - 1) Insulation of shall be 2 lb/ft3 foam insulation with an average R-value of 6 per inch.
    - 2) Insulation water absorption must be no more that 0.038 lb/ft per ASTM D 2842 and show "no growth" per ASTM G21 biocide testing.
    - 3) No insulation shall be exposed to the air stream.
    - 4) Fiberglass insulation is not acceptable due to possibility of sloughing and moisture retention.
- 5. Weatherhood with bird screen shall be provided on outside air inlet.

- 6. Roof shall be pitched with a minimum  $\frac{1}{2}$ " roof overhang around the perimeter of the unit.
- B. Blowers/Motors:
  - 1. Blowers:
    - a. Fan assemblies shall be direct-drive without the use of belts or adjustable sheaves.
    - b. Manufacturer shall provide a variable frequency drive for each fan section.
    - c. Variable frequency drive shall be mounted, wired, and programmed by the manufacturer.
    - d. Variable frequency drive shall be located in an enclosed compartment outside of the supply or exhaust air stream.
    - e. Fan wheel shall be tested in accordance to AMCA 210.
  - 2. Motors:
    - a. Fan motor shall be VFD rated, ODP type, EPACT compliant.
- C. Dampers:
  - 1. Motorized Dampers:
    - a. Frame shall be constructed of a 16 gage galvanized steel hat-channel.
    - b. Blades shall be constructed of 16 gage galvanized steel strengthened by three longitudinal 1 inch deep "vee" grooves.
    - c. Blades shall be symmetrical relative to its axle pivot point.
    - d. Axle bearings shall be synthetic sleeve-type and rotate inside extruded holes in the damper frame.
    - e. Blade seals shall be extruded vinyl permanently bonded to the appropriate blade edges.
    - f. Frame shall include flexible stainless steel compression-type jamb seals.
    - g. Modulating spring-return actuators shall be provided by the factory, installed on the damper, and wired to the control center.
    - h. Damper leakage shall be no more than 5 cfm/sq.ft. at 1 in.wg static pressure.
- D. Filters:
  - 1. Outdoor Air Intake Hood:
    - a. Filter rack shall accommodate 1" media.
    - b. Manufacturer shall provide 1 set of 1" aluminum filter media.
    - c. Filter sections shall be accessible outside the unit and located in the outdoor air intake hood.
  - 2. Outdoor Air Filters:
    - a. Outdoor air filter rack shall accommodate factory-provided 2" MERV 8 filters.
    - b. Filter sections shall be accessible through a 2" foam-injected, double-wall, hinged access door with quarter-turn latches.
  - 3. Supply Air Filters:
    - a. Supply air filter rack shall accommodate 2" MERV 8 filters.

- b. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
- 4. Return Air Filters:
  - a. Return air filter rack shall accommodate factory-provided 2" MERV 8 filters.
  - b. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
- E. Energy Recovery –Flat Plate Heat Exchanger
  - 1. Energy recovery section shall be an integral part of unit from the manufacturer.
  - 2. No field assembly, ducting, or wiring shall be required with energy recovery option.
  - 3. Energy recovery media shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with guarter-turn latches.
  - 4. Flat plate heat exchanger
  - 5. Energy recovery shall be provided through a flat-plate air-to-air heat exchanger providing total energy transfer.
    - a. Total energy transfer shall be without the use of any moving parts, motors, belts, and/or pulleys and meet the latest requirements as listed by ASHRAE 90.1.
    - b. Flat plate heat exchanger shall be constructed with aluminum plates and extruded aluminum framing.
    - c. Individual plates shall be constructed with 0.008" thick, 99.5% pure aluminum with smooth surfaces where exposed to airflow.
    - d. Stainless steel drain pans shall be provided under entire heat exchanger.

# F.

- G. Cooling Air Cooled DX
  - 1. Unit shall be provided with factory piped, charged, and tested packaged air-cooled direct expansion refrigeration system.
  - 2. Refrigeration systems 13 nominal tons and above shall be equipped with two stages of capacity control, each on an independent refrigerant circuit.
  - 3. Refrigeration systems 30 nominal tons and above shall be equipped with four stages of capacity control, two stages per independent circuit.
  - 4. Refrigeration system shall include microprocessor-based head pressure control logic to maintain refrigerant pressures by actively modulating condenser airflow (Active Head Pressure Control).
  - 5. Thermal Expansion Valves:
    - a. Refrigeration system shall be provided with thermal expansion valve (TXV) incorporating adjustable superheat for low load operation.
  - 6. Evaporator Coil:
    - a. Coil shall be rated in accordance to ARI standards and pressure tested for 250 psi working pressure.
    - b. Coil shall be a minimum of 4 rows deep.
    - c. Refrigeration systems with more than one circuit shall have interlaced evaporator coils.
    - d. Coil casing shall be constructed of 16 gage galvanized steel casing.
    - e. Coil tubes shall be constructed of 1/2" diameter, 0.016" thick seamless copper tubing.
    - f. Coil fins shall be constructed of 0.0060" thick aluminum.
  - 7. Drain Pan:

- a. Drain pan shall be constructed of a minimum of 18 gage 201 stainless steel.
- b. Drain pan shall be double-sloped to ensure condensate removal from unit.
- c. Drain pan shall extend a minimum of 8" past the evaporator coil to ensure condensate retention.
- 8. Modulating Hot-Gas Reheat:
  - a. Hot-gas reheat coil shall be separated from the evaporator coil by a minimum of 6" in the direction of airflow to prevent the re-evaporation of condensate, provide room for coil cleaning, and allow control system to monitor evaporator coil leaving air temperature.
  - b. Coil shall be rated in accordance to ARI standards and pressure tested for 250 psi working pressure.
  - c. Coil casing shall be constructed of 16 gage galvanized steel casing.
  - d. Coil tubes shall be constructed of 3/8" diameter, 0.016" thick seamless copper tubing.
  - e. Coil fins shall be constructed of 0.0060" thick aluminum fins.
  - f. Hot-gas reheat shall be controlled through a factory-supplied modulating control valve.
- 9. Condenser Coils:
  - a. Provide condenser coils with galvanized casing, seamless copper tubes, and aluminum fins.
  - b. Coil casing shall be constructed of 16 gage galvanized steel.
  - c. Coil tubes shall be constructed of 3/8" diameter, 0.016" thick seamless copper tubing.
  - d. Coil fins shall be constructed of 0.0060" thick aluminum fins.
- 10. Condensing Fans:
  - a. Condensing section shall be equipped with 1140 rpm direct-drive condensing fans.
  - b. Condensing fan assembly shall be statically and dynamically balanced in accordance with AMCA Standard 204-05.
  - c. Condensing fan assembly shall consist of aluminum-bladed propeller fan wheel, formedchannel base, formed inlet venturi, and coated steel basket guard on the discharge.
- 11. Options:
  - a. Hot gas bypass shall be provided on lead refrigeration circuit.
  - b. Condensing section shall include factory provided and installed condenser coil guards.
- H. Electrical
  - 1. Units shall be factory wired with a single point power connection.
  - 2. Units shall be wired according to NEC and listed per ETL.
  - 3. ETL listing shall cover all components of the ventilator and not be limited to the control panel.
  - 4. All major electrical components shall be UL listed.
  - 5. Unit shall be constructed with an integral control center isolated from supply airflow, exhaust airflow, compressors, and heating elements.
  - 6. The following items shall be provided and wired within the control center by the factory:
    - a. Non-fused disconnect.
    - b. Sub-circuit fusing.
    - c. Low voltage transformers.
    - d. Control circuit fusing.
    - e. Terminal block.
    - f. Fan motor variable frequency drives.
    - g. Factory wired with all control devices installed and wired accepted as noted.
  - 7. Electrical panel must house all high voltage components such as terminal blocks, variable frequency drives, and fuse blocks.
  - 8. Options

- a. Control panel shall include a factory supplied and mounted 115V GFCI convenience outlet receptacle with a 12A circuit breaker. Outlet shall be powered by [factory, others in the field].
- b. Unit shall include a factory supplied, mounted, and wired electric heating element in the control panel to maintain a minimum of 0F in the panel.
- c. Unit shall include a factory supplied, mounted, and wired phase and voltage monitor.
- I. Controls
  - 1. Units shall include factory supplied, mounted, wired, and tested stand-alone microprocessor controls.
  - 2. Microprocessor controller shall be factory-programmed for discharge air control.
  - Microprocessor controller shall be mounted in a weather-proof enclosure and accessible without exposing the operator to high voltage wiring or having to turn off or circumvent the main disconnect.
  - 4. Microprocessor controller shall include local liquid crystal display (LCD) for user interface.
  - 5. The following sensors shall be factory supplied, mounted, and wired inside the unit:
    - a. Outdoor air humidity sensor.
    - b. Outdoor air temperature sensor.
    - c. Evaporator coil leaving air temperature sensor.
    - d. Supply air filter pressure monitoring.
  - 6. The following devices shall be factory supplied but ship loose and require field installation and wiring:
    - a. Wall-mounted room air temperature sensor with manual adjuster.
    - b. Wall-mounted room air humidity sensor.
    - c. Supply air temp temperature sensor.
    - d. Wall-mounted CO2 sensor.
    - e. Space static pressure sensor.
    - f. Duct static pressure sensor.
    - g. Smoke detectors.
  - 7. Microprocessor controller shall include BACnet IP, communications for building management system interface.
  - 8. Microprocessor controller shall include a Web UI interface for remote web-based access.
- J. Factory Verification Testing
  - 1. Unit shall be run tested prior to shipment from the factory.
  - 2. Factory run test report shall be provided at the request of the engineer, contractor, or owner.
  - 3. Testing Procedures
    - a. Unit shall be subjected to and pass a dielectric (hipot) test.
    - b. All motorized dampers shall be cycled one full stroke while installed in the unit using the factory-provided motorized actuators.
    - c. Supply fan
      - 1) Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.

- 2) Verify fan pressure proving switch operation.
- 3) Measure and record current draw through supply fan motor(s).
- 4. Exhaust Fan
  - a. Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.
  - b. Verify fan pressure proving switch operation.
  - c. Measure and record current draw through exhaust fan motor(s).
- 5. Test report shall be included with unit and available from the factory upon request.

### PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.2 INSTALLATION

- A. Install units so supply and exhaust airstreams flow in opposite directions.
- B. Roof Curb: Install on roof structure, level and secure. Install ERU's on curbs and coordinate roof penetrations and flashing with roof construction. Secure ERUs to upper curb rail, and secure curb base to roof framing with anchor bolts.
  - 1. Sloping roof will require special roof curb for unit to mount level.
- C. Install units with clearances for service and maintenance.
- D. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

# 3.3 CONNECTIONS

- A. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination at top of roof curb.
### PROJECT NO. 18-168.00 HARBORCHASE OF FARMINGTON HILLS, MICHIGAN HRA PERMIT SET

- 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
- 3. Install return-air duct continuously through roof structure.
- B. Install condensate drain, minimum connection size, with trap and route down to roof.
- C. Install electrical devices furnished with units but not factory mounted.

## 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections and controls.
- B. Perform tests and inspections.
- C. Tests and Inspections:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

#### 3.5 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and airdistribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

### 3.6 DEMONSTRATION

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

#### END OF SECTION 23 7200

### SECTION 23 7413 - PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:
  - 1. Direct-expansion cooling.
  - 2. Modulating Gas furnace.
  - 3. Economizer outdoor- and return-air damper section.
  - 4. Roof curbs.

#### 1.2 DEFINITIONS

- A. DDC: Direct-digital controls.
- B. ECM: Electrically commutated motor.
- C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- D. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- E. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
- F. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
- G. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring Diagrams: Power, signal, and control wiring.

### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- B. Warranty: Special warranty specified in this Section.

#### 1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### 1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: One set of filters for each unit.

## 1.7 QUALITY ASSURANCE

- A. ARI Compliance:
  - 1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
  - 2. Comply with ARI 270 for testing and rating sound performance for RTUs.
- B. ASHRAE Compliance:
  - 1. Comply with ASHRAE 15 for refrigeration system safety.
  - 2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
  - 3. Comply with applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 "Construction and Startup."
- C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 "Heating, Ventilating, and Air-Conditioning."
- D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.
- E. UL Compliance: Comply with UL 1995.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### 1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AAON, Inc.
  - 2. Rheem.
  - 3. Daikin/McQuay.
  - 4. Trane.
  - 5. JCI/York.

### 2.2 CASING

- A. General Fabrication Requirements for Casings: Formed and reinforced insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs. Unit shall be capable of horizontal (Side) ductwork connection.
- C. Inner Casing Fabrication Requirements:
  - 1. Inside Casing: Galvanized steel.
- D. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
  - 1. Materials: ASTM C 1071, Type I.
  - 2. Thickness: 1/2 inch(13 mm).
  - 3. Liner materials shall have air-stream surface coated with an erosion and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
  - 4. Liner Adhesive: Comply with ASTM C 916, Type I.
- E. Condensate Drain Pans: Non-corrosive material complying with ASHRAE 62.1.
  - 1. Drain Connections: Threaded nipple.
- F. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

- 2.3 FANS
  - A. Direct-Driven Supply-Air Fans: Double width, forward curved, centrifugal; with permanently lubricated, ECM motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.
  - B. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.
  - C. Exhaust-Air Fan: Powered relief fan.
  - D. Fan Motor: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

### 2.4 COILS

- A. Supply-Air Refrigerant Coil:
  - 1. Micro-channel or aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
  - 2. Coil Split: Interlaced.
- B. Outdoor-Air Refrigerant Coil:
  - 1. Micro-channel or aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.

# 2.5 REFRIGERANT CIRCUIT COMPONENTS

- A. Number of Refrigerant Stages:
  - 1. One for 7 tons and smaller.
  - 2. Two for 7.5 tons and larger.
- B. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and hightemperature protection, internal pressure relief, and crankcase heater.
- C. Refrigeration Specialties:
  - 1. Refrigerant: R-410A.
  - 2. Expansion valve with replaceable thermostatic element.
  - 3. Refrigerant filter/dryer.
  - 4. Manual-reset high-pressure safety switch.
  - 5. Automatic-reset low-pressure safety switch.
  - 6. Minimum off-time relay.
  - 7. Automatic-reset compressor motor thermal overload.
  - 8. Brass service valves installed in compressor suction and liquid lines.
  - 9. Hot-gas bypass solenoid valve with a replaceable magnetic coil for operation down to 10% if digital scroll or variable speed compressors are not used.

### 2.6 AIR FILTRATION

- A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
  - 1. Pleated: Minimum 90 percent arrestance, and MERV 8.

### 2.7 GAS FURNACE

- A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.
  - 1. CSA Approval: Designed and certified by and bearing label of CSA.
- B. Burners: Stainless steel.
  - 1. Fuel: Natural gas.
  - 2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
- C. Heat-Exchanger and Drain Pan: Stainless steel.
- D. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
- E. Safety Controls:
  - 1. Gas Control Valve: Modulating.
  - 2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

### 2.8 DAMPERS

- A. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
  - 1. Damper Motor: Modulating with adjustable minimum position.
  - 2. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1, with bird screen and hood.

## 2.9 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

#### 2.10 CONTROLS

A. Controls

- 1. Units shall include factory supplied, mounted, wired, and tested stand-alone microprocessor controls.
- 2. Microprocessor controller shall be factory-programmed for a single space air temperature control.
- Microprocessor controller shall be mounted in a weather-proof enclosure and accessible without exposing the operator to high voltage wiring or having to turn off or circumvent the main disconnect.
- 4. Microprocessor controller shall include local liquid crystal display (LCD) for user interface.
- 5. The following sensors shall be factory supplied, mounted, and wired inside the unit:
  - a. Outdoor air humidity sensor.
  - b. Outdoor air temperature sensor.
  - c. Evaporator coil leaving air temperature sensor.
  - d. Supply air filter pressure monitoring.
- 6. The following devices shall be factory supplied but ship loose and require field installation and wiring:
  - a. Wall-mounted room air temperature sensor with manual adjuster.
  - b. Wall-mounted room air humidity sensor.
  - c. Supply air temp temperature sensor.
  - d. Wall-mounted CO2 sensor.
  - e. Space static pressure sensor.
  - f. Duct static pressure sensor.
  - g. Smoke detectors.
- 7. Microprocessor controller shall include BACnet IP, communications for building management system interface.
- 8. Microprocessor controller shall include a Web UI interface for remote web-based access.
- B. Factory Verification Testing
  - 1. Unit shall be run tested prior to shipment from the factory.
  - 2. Factory run test report shall be provided at the request of the engineer, contractor, or owner.
  - 3. Testing Procedures
    - a. Unit shall be subjected to and pass a dielectric (hipot) test.
    - b. All motorized dampers shall be cycled one full stroke while installed in the unit using the factory-provided motorized actuators.
    - c. Supply fan
      - 1) Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.
      - 2) Verify fan pressure proving switch operation.
      - 3) Measure and record current draw through supply fan motor(s).
  - 4. Exhaust Fan
    - a. Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.
    - b. Verify fan pressure proving switch operation.
    - c. Measure and record current draw through exhaust fan motor(s).

## PROJECT NO. 18-168.00 PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 23 7413 - 7 HRA 10/24/2019 PERMIT SET

### 2.11 ACCESSORIES

- A. Electric heater with integral thermostat maintains minimum 50 deg F(10 deg C) temperature in gas burner compartment.
- B. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
- C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- D. Coil guards of painted, galvanized-steel wire.

### 2.12 ROOF CURBS

- A. Materials: Galvanized steel, 2" vibration isolation with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
  - 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
    - a. Materials: ASTM C 1071, Type I or II.
    - b. Thickness: 1-1/2 inches(38 mm).
  - 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
    - a. Liner Adhesive: Comply with ASTM C 916, Type I.
    - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    - d. Liner Adhesive: Comply with ASTM C 916, Type I.
- B. Curb Height: Minimum of 14 inches(355 mm).

#### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.

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

### 3.2 INSTALLATION

A. Roof Curb: Install on roof structure, level and secure. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction.

### 3.3 CONNECTIONS

- A. Install condensate drain, minimum connection size, with trap and route down to roof.
- B. Install piping adjacent to RTUs to allow service and maintenance.
  - 1. Gas Piping: Comply with applicable requirements in Division 23 Section "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- C. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination at top of roof curb.
  - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
  - Connect supply ducts to RTUs with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."
  - 4. Install return-air duct continuously through roof structure.

## 3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
  - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
  - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

#### 3.5 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and do the following:

PROJECT NO. 18-168.00	PACKAGED, OUTDOOF	R, CENTRAL-STATION AIR-H	ANDLING UNITS
HARBORCHASE OF FARMINGTON HILL	S, MICHIGAN		23 7413 - 9
HRA			10/24/2019
PERMIT SET			

- 1. Inspect for visible damage to unit casing.
- 2. Inspect for visible damage to furnace combustion chamber.
- 3. Inspect for visible damage to compressor, coils, and fans.
- 4. Inspect internal insulation.
- 5. Verify that labels are clearly visible.
- 6. Verify that clearances have been provided for servicing.
- 7. Verify that controls are connected and operable.
- 8. Verify that filters are installed.
- 9. Clean condenser coil and inspect for construction debris.
- 10. Clean furnace flue and inspect for construction debris.
- 11. Connect and purge gas line.
- 12. Remove packing from vibration isolators.
- 13. Verify lubrication on fan and motor bearings.
- 14. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
- 15. Adjust fan belts to proper alignment and tension.
- 16. Start unit according to manufacturer's written instructions.
  - a. Start refrigeration system.
  - b. Do not operate below recommended low-ambient temperature.
  - c. Complete startup sheets and attach copy with Contractor's startup report.
- 17. Inspect and record performance of interlocks and protective devices; verify sequences.
- 18. Operate unit for an initial period as recommended or required by manufacturer.
- 19. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
  - a. Measure gas pressure on manifold.
  - b. Inspect operation of power vents.
  - c. Measure combustion-air temperature at inlet to combustion chamber.
  - d. Measure flue-gas temperature at furnace discharge.
  - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
  - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
- 20. Calibrate thermostats.
- 21. Adjust and inspect high-temperature limits.
- 22. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
- 23. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F(8 deg C) above return-air temperature:
  - a. Coil leaving-air, dry- and wet-bulb temperatures.
  - b. Coil entering-air, dry- and wet-bulb temperatures.
  - c. Outdoor-air, dry-bulb temperature.
  - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
- 24. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
- 25. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

- a. Supply-air volume.
- b. Return-air volume.
- c. Relief-air volume.
- d. Outdoor-air intake volume.
- 26. Simulate maximum cooling demand and inspect the following:
  - a. Compressor refrigerant suction and hot-gas pressures.
  - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
- 27. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
  - a. High-temperature limit on gas-fired heat exchanger.
  - b. Low-temperature safety operation.
  - c. Filter high-pressure differential alarm.
  - d. Economizer to minimum outdoor-air changeover.
  - e. Relief-air fan operation.
  - f. Smoke and firestat alarms.
- 28. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

## 3.6 CLEANING AND ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.
- B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

## 3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain RTUs. Refer to Division 01 Section "Demonstration and Training."

## END OF SECTION 23 7413

# SECTION 238126 – VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 - GENERAL

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

### 1.2 SUMMARY

- A. Section includes complete Variable Refrigerant Flow (VRF) HVAC system(s) including, but not limited to, delegated design and the following components to make a complete operating system(s) according to requirements indicated:
  - 1. Outdoor, three-phase, air-source heat pump & heat recovery condensing units.
  - 2. Outdoor, single-phase, air-source heat pump & heat recovery condensing units.
  - 3. Indoor, heat recovery boxes.
  - 4. Indoor, ceiling concealed, high-static ducted fan coil units.
  - 5. Complete VRF Control System.
  - 6. VRF Refrigeration Piping Requirements.
  - 7. VRF Manufacturer's engineering and installation support qualifications.
  - 8. VRF Installer Qualifications and Execution.
- B. <u>Control System Scope of Work:</u> The VRF System Manufacturer shall provide all materials and labor for complete and fully operational system of controls with all materials, engineering, technician's labor, programming, integration labor and warranty including:
  - 1. Equipment called out in Specifications Section 23 0900 Instrumentation and Controls for HVAC
  - 2. Project specific control drawings (in Revit or AutoCad format) for review and as-builts
  - 3. Custom built, UL Listed control panels with power supply, controllers, Ethernet switches, etc. as described herein.
  - 4. BACnet BTL listed B-BC building controller(s) for all VRF system control and monitoring functions with local web user interface
  - 5. All integration and programming labor for VRF System BACnet BTL listed B-BC building controller(s) commination to Bedrock Supervisory Control, including:
    - a. All point mapping and integration using Haystack Tagging over Fox Ethernet
    - b. Data Normalization management over the network
- C. <u>Proposal Requirements:</u> VRF System manufacturer shall include a detailed technical proposal for equipment and control system describing:
  - 1. All VRF equipment and VRF control devices
  - 2. Control system components including quantity of building controllers, custom panels and other control devices
  - 3. Basic Riser diagram of control system indicating panel locations, wiring, Ethernet network and devices.

#### PROJECT NO. 18-168.00 HARBORCHASE OF FARMINGTON HILLS, MICHIGAN HRA PERMIT SET

- 4. Labor for control system, integration and warranty.
- 5. Bios for Niagara Certified Technicians, Control Engineer(s) and other key manufacturer representative's employees.
- 1.3 DEFINITIONS
  - A. <u>Variable Refrigerant Flow (VRF) HVAC System</u>: Variable capacity, direct expansion (DX) field-selectable heat pump or heat recovery engineered system within a single condensing unit cabinet. The outdoor unit consists of one or more frames connected through a common 2-pipe heat pump or 3-pipe heat recovery refrigerant piping network and control communication wiring. Each system consists of single or multiple inverter-driven compressor(s). Each system may be connected to multiple indoor units (ducted, non-ducted, or mixed combinations) through a common refrigerant piping network and integrated system controls and communication network. Each indoor unit may be controlled individually or as a group.
  - B. <u>Heat Pump System Operation</u>: VRF system only capable of operation in either heating or cooling mode across all zones served by a single VRF condensing unit. Heat pump VRF systems utilizing a two-pipe system design consist of one high pressure refrigerant vapor line one refrigerant liquid line connected to a single VRF condensing unit or multiple-manifolded VRF condensing units in a single system to associated system indoor fan coil units.
  - C. <u>Heat Recovery System Operation</u>: VRF system capable of operation with simultaneous heating and cooling between multiple zones served by a single VRF condensing unit. Heat recovery VRF systems utilizing a threepipe system design consist of one high pressure refrigerant vapor line, one medium pressure refrigerant vapor line, and one refrigerant liquid line connected to a single VRF condensing unit or multiple-manifolded VRF condensing units in a single system to associated system Heat Recovery Boxes. One refrigerant liquid line and one refrigerant vapor line connect Heat Recovery Boxes to associated indoor fan coil units.
  - D. <u>Heat Recovery Box (HR Box)</u>: HR Boxes are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit (HRCU) is the term used by ASHRAE for what different manufacturers term as HR box, branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.
  - E. <u>Low Voltage</u>: As defined in NFPA 70 for circuits and equipment operating at less than 50V, or for remotecontrol, signaling power-limited circuits.
  - F. <u>Plenum</u>: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
  - G. <u>Controls</u>:
    - 1. BACnet MS/TP: BACnet communication utilizing Master slave/token passing.
    - 2. BACnet IP: BACnet communication utilizing Internet Protocol.
    - 3. API: Application Program Interface.
    - 4. JACE: JAVA Application Control Engine.
    - 5. IoT: Internet of Things.

- 1.4 VRF CONTROLS SYSTEM ARCHITECTURE
  - A. All VRF Control Components provided and installed under this specification shall be a complete system from a single manufacturer (unless otherwise specified) and shall be designed for access on the client's network.
  - B. The VRF Controls System shall include, but not be limited to:
    - 1. Central Controller/ VRF JACE Integration Device.
    - 2. Local Zone Controllers
    - 3. Room Temperature Sensors (where applicable)
    - 4. Dry Contact Kits (where applicable)
    - 5. Specialty Application Controllers (where applicable)
  - C. The Central Controller VRF JACE Integration Device shall be the main connection to the client's network and BAS, connected via a high-speed CAT 6 communication wire.
  - D. The Premium Local Zone Controllers BACnet MS/TP network shall be the secondary connection to the client's BAS via a twisted pair. If the Central Controller JACE Integration Device shall ever fail to communicate, the BAS shall utilize the BACnet MS/TP Network to communicate and control the VRF System.

## 1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated:
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - 2. Include construction details, material descriptions, dimensions or individual components and profiles, installation and service clearances, and finishes for indoor units, heat recovery boxes, and condensing units.
  - 3. Include operating performance data at design conditions, and at extreme maximum and minimum outdoor ambient conditions.
  - 4. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
  - 5. Include refrigerant piping network diagrams indicating a comprehensive breakdown of VRF equipment model numbers, actual heating and cooling capacities at design outdoor ambient conditions, refrigerant pipe lengths, quantities and sizes between VRF condensing units, HR boxes, and indoor fan coil units. Refrigerant piping network diagrams shall include data indicating compliance with requirements indicated. Refrigerant piping network diagrams shall be generated by the manufacturer's specific equipment selection software.
  - 6. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements and connections.
  - 7. Include description of control software features.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and mounting details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams and details of refrigerant piping, showing installation requirements for manufacturerfurnished divided flow fittings.
  - 4. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittals:

- 1. Include design calculations with corresponding diagram of refrigerant piping sizing for each system installed (Refer to section 1.4.A.5 for additional requirements).
- 2. Include design calculations indicating that refrigeration concentration limits (RCL) are within allowable limits of ASHRAE 15 and governing codes.
- 3. Include calculations showing that system travel distance for refrigerant piping and control wiring are within horizontal and vertical travel distances set by manufacturer.

# 1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, utilizing input from installers of the items involved:
  - 1. Suspended ceiling components.
  - 2. Structural floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
  - 3. Size and location of initial access modules for acoustical tile.
  - 4. Wall-mounted controllers located in finished space showing relationship to light switches, fire alarm devices, and all other installed devices.
  - 5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
  - 6. Items penetrating finished ceiling including the following:
    - a. Luminaires.
    - b. Air outlets and inlets.
    - c. Speakers.
    - d. Sprinklers.
    - e. Service access panels.
- B. Qualification Data:
  - 1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed all perquisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
    - a. Retain copies of Installer certificates on-site and make available on request.
  - 2. For VRF HVAC system manufacturer.
  - 3. For VRF HVAC system provider.
- C. Warranty:
  - 1. Equipment: Manufacturer's standard and extended warranty indicating all terms, Installer requirements, duration, and provisions.
  - 2. Controls and Installation: One year parts and labor M-F, 7AM to 5PM
- D. Data Communications Protocol Certificates: Certify that any BACnet communication device complies with ASHRAE 135.
  - 1. Include BACnet Instance point reference guide for assistance with integration.
  - 2. Include BTL Listing for all control and network devices
  - 3. Provide PIC statement of conformance for each controller

# 1.7 CONTROL SYSTEM SUBMITTALS

- 1. Provide large format (11x17 minimum) control drawings with complete riser diagram showing all system components and panel locations by floor
- 2. Show point to point wiring for all control devices with wire tagging and color coding that will be used in the field. Include wiring specs on the schematic diagram for each wire type with termination details showing how to trim shield and drain wire.
- 3. Provide UL Panel Shop layout drawings and internal wiring diagrams with all wiring clearly labeled and cross referenced to terminal numbers
- 4. Provide summary material list of all controllers and devices with manufacturer's data sheets for each device.
- 5. Include detailed points list for all controllers and I/O. Include BLT listing and PIC statements for all controllers and the VRF Building Controller/JACE Interface.

# 1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Project specific for VRF HVAC Systems and controls to include in emergency, operation, and maintenance manuals.
- B. Update control drawings to march installed wiring and terminal numbering.
- C. Software and Firmware Operational Documentation:
  - 1. Software operating and upgrade manuals.
  - 2. Program Software Backup: On USB media or approved cloud storage platform, complete with data files.
  - 3. Detailed device address list including the following parameters:
    - a. Unit Tag
    - b. Associated Condensing Unit
    - c. Associated Room Tag
    - d. Central Controller Address
    - e. All required control and monitor points, including BACnet Instance numbers
  - 4. Printout of software application and graphic screens.

## 1.9 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: One set(s) for each air-handling unit.
  - 2. Indoor Units: One for each unique size and type installed, available locally on request by VRF HVAC system provider.
  - 3. Controllers for Indoor Units: Six for each unique controller type installed, available locally on request by VRF HVAC system provider.

## 1.10 QUALITY ASSURANCE

## A. Manufacturer Qualifications:

- 1. Nationally Recognized manufacturer of VRF HVAC systems, controls, and products.
- 2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
- 3. VRF HVAC systems, controls, and products that have been successfully tested and currently in-use on at least five completed projects.

- 4. Having complete and up-to-date published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
- 5. Having full-time in-house employees for the following:
  - a. Product and research development.
  - b. Product and application engineering.
  - c. Product manufacturing, testing, and quality control.
  - d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
  - e. Owner training.
- B. Factory-Authorized VRF HVAC Equipment Representative Qualifications:
  - 1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
  - 2. Demonstrated past experience with VRF products being installed for a minimum period of five consecutive years before time of bid.
  - 3. Demonstrated past experience on ten projects of similar complexity, scope, and value.
  - 4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule, with a minimum of one state-licensed professional engineer on staff.
  - 5. Technical support staff assigned to support project throughout entire warranty period.
  - 6. Local product and parts inventory capable of supporting ongoing systems operation for entire duration of manufacturer's extended warranty period, or ten years after Substantial Completion.
  - 7. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.
  - 8. Niagara 4 Certified personnel on staff.
- C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.
  - 1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
  - 2. Installer certification shall be valid and current for duration of Project.
  - 3. Retain copies of Installer certificates on-site and make available on request.
  - 4. Each person assigned to Project shall have demonstrated past experience:
    - a. Demonstrated past experience with similar products being installed for period within five consecutive years prior to time of bid.
    - b. Demonstrated past experience on five projects of similar complexity, scope, and value.
  - 5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.
  - 6. Installers shall have technical support staff assigned to support project throughout entire manufacturer's warranty period
- D. Certified Performance Ratings: VRF HVAC systems shall bear published performance ratings certified by AHRI (Air Conditioning, Heating, and Refrigeration Institute) and listed in the AHRI Standard 1230 certified product directory.
- E. Product Certifications: All VRF HVAC system components shall be manufactured in production facilities maintaining the following ISO certifications:
  - 1. ISO 9001 Quality Management System.
  - 2. ISO 14001 Environmental Management System.

- F. UL/ETL Certification: All VRF HVAC components shall comply with Underwriters Laboratories (UL) 1995 4<sup>th</sup> edition of Heating and Cooling Equipment Standard for Safety and bear the Electrical Testing Laboratories (ETL) mark.
- G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. All VRF HVAC system electrical power wiring shall be installed according to the National Electrical Code (NEC) or applicable state and local building codes.
- H. Compliance:
  - 1. Michigan Mechanical Code 2015 Chapter 11 Refrigeration
    - a. 1104.2.1 Institutional Occupancies
  - 2. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
  - ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."
- I. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
- 1.11 DELIVERY, STORAGE, AND HANDLING
  - A. Deliver and store products in a clean dry place.
  - B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
  - C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
  - D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
    - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove immediately prior to operation.
    - Cover unit openings before installation to prevent dirt and dust from entering inside of units. If
      required to remove coverings during equipment installation, reapply coverings over openings after
      installation and remove immediately prior to operation.
  - E. Replace all installed products damaged during installation.

- 1.12 WARRANTY
  - A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail in materials or workmanship within specified warranty period.
    - 1. Failures include, but are not limited to, the following:
      - a. Structural failures.
      - b. Faulty operation.
      - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
    - 2. Manufacturer's Standard Warranty: VRF system shall be warranted by the manufacturer's limited warranty for replacement of malfunctioning components and specific software upgrades to meet application engineering needs for one (1) year from the date of original installation, or eighteen (18) months from date of manufacture.
      - a. For Compressor: 7 years from date of start-up or substantial completion.
      - b. For Parts: 2 years from date of start-up or substantial completion.
      - c. For Controls: 1 year from date of start-up or substantial completion.
    - 3. Manufacturer's Extended Warranty: The standard warranty period for compressor(s) and parts are extended as indicated below for qualified systems. System shall be installed by a licensed mechanical contractor trained by the VRF equipment manufacturer or installation professional. Commissioning shall be performed by the VRF manufacturer, certified VRF manufacturer equipment provider, or trained and certified installation professional. Commissioning results shall be entered into manufacturers' online commissioning system within sixty (60) days of system startup.
      - a. For Compressor: 10 years from date of start-up or substantial completion.
      - b. For Parts: 10 years from date of start-up or substantial completion.
      - c. For Controls: 1 year from date of start-up or substantial completion.
      - d. For Labor: 1 year from date of start-up or substantial completion.

# PART 2 - PRODUCTS

- 2.1 MANUFACTURERS
  - A. Basis-of-Design Product: Basis-of-Design shall be LG Electronics.
  - B. Subject to compliance with requirements provide products by one of the following.
    - 1. Dyken Mcquay/Airtech
    - 2. Johnson Controls Corporate/Hitachi.
    - 3. Train/Mitsubishi.
  - C. System Performance Documentation:
    - The VRF HVAC manufacturer shall provide published outdoor unit performance data in table format which states the product heating and cooling capacities expressed in British thermal units per hour (BtuH) and power consumption expressed in kilowatts (kW) at a minimum of 8 possible combinations of allowed conditions between 50% and 130% connection ratio. Possible combinations of allowed condition variables include Combination Ratios expressed as a percentage value, Outdoor Ambient Temperature expressed in degrees Fahrenheit (°F), and indoor unit Entering Air wet and dry bulb temperature expressed in degrees Fahrenheit (°F). Any product whose system design and

engineering manuals or guides where published data tables are expressed in units other than these specified will not be accepted.

- 2. Any product whose published documentation requires the design engineer to apply a correction factor derived from a published curve or tabular data for combination ratio, outdoor ambient temperature, and/or entering air temperature against rated conditions to obtain performance at any possible combination of allowed conditions will not be accepted.
- 3. VRF Systems with Onboard Alternate Operating Mode Capability:
  - a. All VRF systems which provide field selectable Alternate Operating Modes, for example, High Heat or High Ambient Cooling, published data tables must be available to the public for all modes offered.
  - b. Acceptable Alternate Operating Modes must ship with all models of the VRF product offering and must be factory embedded. Custom factory or field modifications to factory provided algorithms created to meet scheduled requirements are not acceptable.
  - c. Provide a copy of instructions required to set the Alternate Operation Mode with the initial submittal.
  - d. For systems that provide field selectable Alternate Operating Modes, ALL technical data provided in the submittal data sheets showing product rated condition performance data, must also provide separate data sheets that show product performance data at each of the field selectable Alternate Operating Modes available. Capacity, power input, and acoustic performance data for each mode offered shall be reported separately. Mixing of ODU, IDU, or VRF system performance capability operating in one mode with for example the power consumption, sound power rating, or electrical requirements of the same system operating in another mode is not acceptable.

# 2.2 SYSTEM DESCRIPTION

A. The VRF HVAC system shall be an air- or water-cooled system allowing user to configure in the field a heat pump or a heat recovery system consisting of one to three outdoor unit modules, conjoined to make a 6-42 ton single refrigerant circuit. Heat recovery systems, employing three pipes, shall be connected to Heat recovery (heat recovery) unit(s) and indoor unit(s). Multi-port heat recovery units shall allow simultaneous heating and cooling of individual zone(s) at various capacities as required to satisfy their zone requirements. Heat pump systems shall require two pipes, simultaneous heating and cooling shall not be supported. The heat recovery systems shall only consist of three pipes, liquid, suction and hot gas pipes. Two pipe heat recovery systems that cannot deliver, at zero degrees outdoor ambient (where applicable), 162°F hot gas to the indoor coils for heat shall not be acceptable.

# 2.3 OUTDOOR, THREE PHASE, AIR-SOURCE HEAT PUMP & HEAT RECOVERY CONDENSING UNITS

- A. Description: The VRF HVAC system shall be an air-cooled system allowing user to configure in the field a heat pump or a heat recovery system consisting of one to three outdoor unit modules, conjoined to make a 6-42 ton single refrigerant circuit.
- B. General:
  - 1. The outdoor unit shall be specifically used with the associated manufacturer's indoor units and accessories. The outdoor units shall be equipped with multiple circuit boards that interface manufacturer's controls system and shall perform all functions necessary for operation. Each outdoor unit module shall be completely factory assembled, piped, wired, and run tested at the factory.

- 2. Product Generation: All three-phase VRF heat pump and heat recovery outdoor units shall be from the same product development generation. Mixing of outdoor units from different development generations is not acceptable.
- 3. Each system shall consist of one, two or three air source outdoor unit modules conjoined together in the field to result in the capacity specified elsewhere in the project documents.
- 4. Dual and triple frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kits and field provided interconnecting pipe to form a common refrigerant circuit.
- 5. The sum of connected capacity of all indoor air handlers shall range from 50% to 130% of outdoor unit rated capacity.
- 6. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
- 7. Operating Conditions: Outdoor Unit shall be capable of continuous compressor operation between the following operating ambient air conditions. Operation outside of these conditions are possible and may involve non-continuous operations.
  - a. Operating Ambient Air Conditions
    - 1) Heat Pump and Heat Recovery Systems
      - a) Cooling: 5°F DB to 122°F DB (With optional low ambient kit from -9.9°F DB to 122°F DB)
      - b) Heating: -22°F WB to 61°F WB
      - c) Cooling Based Synchronous: 14°F DB to 81°F DB (Heat Recovery Operation Only)
      - d) Heating Based Synchronous: 14°F WB to 61°F WB (Heat Recovery Operation Only)
- 8. The VRF HVAC System shall use R-410A refrigerant.
- 9. The system shall be capable of an automatic variable refrigerant charge function for use in both the heat mode and cool mode to ensure the proper amount of circulating refrigerant is in the system. Manufactures that cannot control, in real time, the amount of circulating refrigerant to ensure optimal system operation year-round shall not be allowed.
- 10. Cabinet weights and foot prints shall vary between 430 lbs., 7.61 sq. ft. (1.27 sq. ft. per ton), for 6 ton cabinet to 666 lbs., 10.14 sq. ft. (.51 sq. ft. per ton), for 20 ton cabinet for single cabinet configurations. Multi cabinet configurations shall be per specifications. (Install setbacks and service areas not included).
- 11. Each VRF outdoor condensing unit shall have factory-supplied drain pan heater kits installed to prevent build-up of ice accumulated during defrost operation.
- C. Outdoor Unit Refrigeration Circuit: Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:
  - 1. Refrigerant strainer(s).
  - 2. Check valve(s).
  - Inverter-driven, medium pressure vapor injection, high pressure shell compressors, designed, built, and provided by VRF HVAC manufacturer. VRF HVAC outdoor units provided with compressors manufactured by a third party will not be accepted.
  - 4. Liquid refrigerant cooled inverter PCB.
  - 5. Oil separator(s).
  - 6. Accumulator / controlled volume receiver(s).
  - 7. 4-way reversing valve(s).
  - 8. Vapor injection valve(s).
  - 9. Variable path heat exchanger control valve(s).
  - 10. Oil balancing control.
  - 11. Oil level sensor(s).
  - 12. Electronic expansion valve(s).

- 13. Sub-cooler(s).
- 14. High and low Schrader valve service ports with caps.
- 15. Service valves.
- 16. Factory supplied refrigerant charge, pounds.
- D. Compressor:
  - 1. Outdoor units shall be equipped with inverter driven scroll hermetic compressor(s) only. Non inverterdriven compressors, which cause inrush current (demand charges) and require larger wire sizing, shall not be allowed.
  - 2. All compressors shall have flash injection for effective low outdoor temperature heating performance.
  - 3. A crankcase heater(s) shall be factory mounted on the compressor(s), controlled by oil temperature.
  - 4. Each inverter-driven scroll compressor shall be capable of operating from 12 Hz up to 150 Hz with control in 0.5 Hz increments in any and all modes (heating, cooling, or synchronous modes).
  - 5. The compressor(s) shall be protected with:
    - a. High pressure switch.
    - b. Over/under current protection.
    - c. Oil sump sensor.
    - d. Phase failure.
    - e. Phase reversal.
    - f. Compressor shall be capable of receiving injection of medium pressure gas at a point in the compression cycle where such injection shall allow a greater mass flow of refrigerant at lower outdoor ambient and achieving a higher heating capability. The VRF outdoor unit shall have published performance data for heating mode operation down to -13°F on both heat pump and heat recovery systems.
  - 6. The compressor shall be mounted on rubber isolators to avoid the transmission of vibration.
  - 7. Compressor Operation: The VRF systems shall be capable of providing continuous compressor operation over the required ambient operating range stated in section 2.3.B.7. VRF systems that provide possible, but don't guarantee continuous compressor operation over the required ambient operating range stated in section 2.3.B.7, will not be accepted. Submittal that states performance data is reference data, data that is for reference only, or that is footnoted as such shall not be accepted.
  - 8. Compressor bearing surfaces shall be coated with Teflon® equal. Bearings shall be lubricated using a constant flow of PVE refrigerant oil to the bearing surfaces The film of oil separating the crankshaft journals and bearing surfaces shall be consistent at all times the crankshaft is in motion and shall be maintained irrelevant of crankshaft rotational speed.
  - 9. Compressor Control: Fuzzy control logic shall establish and maintain target evaporating temperature (Te) to be constant on cooling mode and condensing temperature (Tc) constant on heating mode by Fuzzy control logic to ensure the stable system performance. Other compressor control capabilities shall be available via special function controls as noted elsewhere in this specification.
- E. Inverter Compressor Controller(s):
  - The VRF outdoor unit shall be provided with a separate inverter compressor controller PCB for each compressor. Inverter compressor controllers that host more than one compressor shall not be accepted.
  - 2. The inverter compressor controller shall be designed and programmed to utilize the entire range of operation of the connected compressor during cooling cycle operation and/or heating cycle operation.
- F. Vapor Injection Circuit:
  - 1. VRF outdoor unit shall have a medium pressure gas vapor injection function employed in the heating and cooling modes to increase system capacity when the outdoor ambient temperatures are low and

lower compressor lift when temperatures are high. The compressor vapor injection flow amount shall be controlled by the vapor injection sub-cooling algorithm reset by discharge gas temperatures of the compressor.

- G. Heat Exchanger Circuit:
  - 1. Outdoor unit heat exchanger shall be comprised of aluminum fins mechanically bonded to copper tubing and shall be four sided and 2 or 3 rows deep and 17 fins per inch.
  - 2. The copper tubes shall have inner riffling to expand the total surface of the tube interior.
  - 3. The aluminum fins shall have a factory applied heat exchanger coating that is comprised of a highly corrosion resistant epoxy resin coating, 1.6-2.0 um thick, designed to perform in corrosive environments such as contaminated and humid conditions. The heat exchanger protection shall include a Hydrophilic coating which minimizes moisture buildup on the fin heat exchanger. The heat exchanger shall have been tested to the following conditions:
    - a. ASTM B-117 Salt spray test 1500 hours with no corrosion.
    - b. Acid salt test 900 hours .02% corrosion.
    - c. ASM corrosion test 3,000 hours. The heat exchanger coating shall be certified by underwriters Laboratories and per ISO 21207. The above conditions shall establish the minimum allowable performance which all alternates must comply.
  - 4. Shall be designed, built and provided by the VRF outdoor unit manufacturer.
  - 5. The outdoor unit coil, all indoor units and pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or allow field testing at 550 psig shall not be allowed.
  - 6. The outdoor unit coil for each cabinet shall have lanced aluminum fins with a maximum fin spacing of no more than 17 Fins per Inch (FPI). All the outdoor unit coils shall be 2 or 3 rows, consisting of staggered tubes for efficient air flow across the heat exchanger.
  - 7. The cabinet shall have a factory installed coil guard.
- H. Refrigeration Oil:
  - 1. Each compressor shall ship from the factory with a full charge of Polyvinylether (PVE) refrigerant oil. Any additional oil required by manufacturer to initially commission the system shall be provided and shipped to the jobsite by the VRF manufacturer at no charge to the installer.
    - a. The refrigerant oil supplied shall have a flash point rating of no less than 395°F.
    - b. VRF systems that utilize refrigerant oils that can "hydrolyze" and result in capillary tube or strainer blockage when mixed with water vapor, such as Polyol Ester (POE), are not acceptable.
- I. Cabinet:
  - Outdoor unit cabinet shall be made of minimum 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours.
  - 2. The front panels of the outdoor units shall be removable type for access to internal components.
  - 3. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.
- J. Fan Assembly:
  - 1. Each outdoor unit frame shall be equipped with one or two direct-drive, variable speed propeller fan with variable speed, inverter driven, Brushless Digitally Commutated (BLDC) motor with a vertical discharge.
  - 2. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
  - 3. The fan(s) motor shall be equipped with permanently lubricated bearings.

- 4. The fan motor shall be variable speed with an operating speed range of 0-1150 RPM cooling mode and 0-1150 RPM heating mode.
- 5. The fan shall have a guard to help prevent contact with moving parts.
- 6. The cabinet shall have option to redirect the discharge air direction from vertical to horizontal with the addition of optional factory provided air guides.
- 7. The fan controller shall have a DIP switch setting to raise external static pressure of the fan up to 0.32 inch of W.C. to accommodate ducted installations.
- K. Operational Sound Levels:
  - Each single frame outdoor unit shall be rated with an operational sound pressure level not to exceed 63 dB(A) when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their equipment at other than tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available and the highest field selectable conditions shall not be allowed.
- L. Sensors:
  - 1. Each outdoor unit module shall have the following sensors:
    - a. Suction temperature sensor.
    - b. Discharge temperature sensor.
    - c. Oil level sensor.
    - d. High pressure sensor.
    - e. Low pressure sensor.
    - f. Outdoor temperature sensor.
    - g. Outdoor humidity sensor.
    - h. Outdoor unit heat exchanger temperature sensors.

## M. Electrical:

- 1. The outdoor unit electrical power shall be 208V / 3 Phase or 460V / 3 Phase, and 60 hertz.
- 2. The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.

## 2.4 OUTDOOR, SINGLE PHASE, AIR-SOURCE HEAT PUMP & HEAT RECOVERY CONDENSING UNITS

- A. Description: The VRF HVAC system shall be an air-cooled system allowing user to configure in the field a heat pump or a heat recovery system consisting of one outdoor unit module, conjoined to make a 2-5 ton (heat pump) or 5-ton (heat recovery) single refrigerant circuit.
- B. General:
  - 1. The outdoor unit shall be specifically used with the associated manufacturer's indoor units and accessories. The outdoor units shall be equipped with multiple circuit boards that interface manufacturer's controls system and shall perform all functions necessary for operation. Each outdoor unit module shall be completely factory assembled, piped, wired, and run tested at the factory.
  - 2. Product Generation: All single-phase VRF heat pump and heat recovery outdoor units shall be from the same product development generation. Mixing of outdoor units from different development generations is not acceptable.

- 3. The sum of connected capacity of all indoor air handlers shall range from 50% to 130% of outdoor unit rated capacity.
- 4. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
- 5. Operating Conditions: Outdoor Unit shall be capable of continuous compressor operation between the following operating ambient air conditions. Operation outside of these conditions are possible and may involve non-continuous operations.
  - a. Operating Ambient Air Conditions
    - 1) Heat Pump and Heat Recovery Systems
      - a) Cooling: 23°F DB to 122°F DB (With optional low ambient kit from -9.9°F DB to 122°F DB)
      - b) Heating: -13°F WB to 61°F WB
      - c) Cooling Based Synchronous: 14°F DB to 81°F DB (Heat Recovery Operation Only)
    - d) Heating Based Synchronous: 14°F WB to 61°F WB (Heat Recovery Operation Only)
- 6. The VRF HVAC System shall use R-410A refrigerant.
- 7. Each VRF outdoor condensing unit shall have factory-supplied drain pan heater kits installed to prevent build-up of ice accumulated during defrost operation.
- C. Outdoor Unit Refrigeration Circuit: Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:
  - 1. Refrigerant strainer.
  - 2. Check valve.
  - Inverter-driven, medium pressure vapor injection, high pressure shell compressors, designed, built, and provided by VRF HVAC manufacturer. VRF HVAC outdoor units provided with compressors manufactured by a third party will not be accepted.
  - 4. Oil separator.
  - 5. Accumulator / receiver.
  - 6. 4-way reversing valve.
  - 7. Electronic expansion valve.
  - 8. Sub-cooler.
  - 9. High and low Schrader valve service ports with caps.
  - 10. Service valves.
  - 11. Threaded fusible plug.
  - 12. High pressure switch.
  - 13. Factory supplied refrigerant charge, pounds.
- D. Compressor:
  - 1. Outdoor units shall be equipped with inverter driven scroll hermetic compressor(s) only. Non inverterdriven compressors, which cause inrush current (demand charges) and require larger wire sizing, shall not be allowed.
  - 2. A crankcase heater shall be factory mounted on the compressor, controlled by oil temperature.
  - 3. The heat pump outdoor unit inverter-driven scroll compressor shall be capable of operating from 20 Hz up to 90 Hz with control in 1.0 Hz increments in any and all modes (heating or cooling).
  - 4. The heat recovery outdoor unit inverter-driven scroll compressor shall be capable of operating from 12 Hz up to 110 Hz with control in 1.0 Hz increments in any and all modes (heating, cooling, or synchronous).
  - 5. The compressor shall be protected with:
    - a. High pressure switch.
    - b. Over/under current protection.

- c. Phase failure.
- d. Phase reversal.
- 6. The compressor shall be mounted on rubber isolators to avoid the transmission of vibration.
- 7. Compressor Operation: The VRF systems shall be capable of providing continuous compressor operation over the required ambient operating range stated in section 2.5.B.5. VRF systems that provide possible, but don't guarantee continuous compressor operation over the required ambient operating range stated in section 2.5.B.5, will not be accepted. Submittal that states performance data is reference data, data that is for reference only, or that is footnoted as such shall not be accepted.
- 8. Compressor bearing surfaces shall be coated with Teflon® equal. Bearings shall be lubricated using a constant flow of PVE refrigerant oil to the bearing surfaces The film of oil separating the crankshaft journals and bearing surfaces shall be consistent at all times the crankshaft is in motion and shall be maintained irrelevant of crankshaft rotational speed.
- 9. Compressor Control: Fuzzy control logic shall establish and maintain target evaporating temperature (Te) to be constant on cooling mode and condensing temperature (Tc) constant on heating mode by Fuzzy control logic to ensure the stable system performance. Other compressor control capabilities shall be available via special function controls as noted elsewhere in this specification.
- E. Inverter Compressor Controller:
  - 1. The inverter compressor controller shall be designed and programmed to utilize the entire range of operation of the connected compressor during cooling cycle operation and/or heating cycle operation.
- F. Heat Exchanger Circuit:
  - 1. Outdoor unit coil shall be comprised of aluminum fins mechanically bonded to copper tubing with inner surfaces having a riffling treatment to expand the total surface of the tube interior
  - 2. The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant coating. The coil coating shall be tested per ASTM B-117 standard. The test shall be performed for a minimum of 1000 hours. The outdoor unit coil shall have a minimum of 2 rows.
  - 3. The outdoor unit coil shall have a minimum of 14 Fins per Inch (FPI).
  - 4. The outdoor unit coil, all indoor units and the interconnecting field provided pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or specify field testing pressures at less than 550 psig shall not be acceptable.
  - 5. Shall be designed, built and provided by the VRF outdoor unit manufacturer.
  - 6. The cabinet shall have a factory installed coil guard.
- G. Refrigeration Oil:
  - 1. Each compressor shall ship from the factory with a full charge of Polyvinylether (PVE) refrigerant oil. Any additional oil required by manufacturer to initially commission the system shall be provided and shipped to the jobsite by the VRF manufacturer at no charge to the installer.
    - a. The refrigerant oil supplied shall have a flash point rating of no less than 395°F.
    - b. VRF systems that utilize refrigerant oils that can "hydrolyze" and result in capillary tube or strainer blockage when mixed with water vapor, such as Polyol Ester (POE), are not acceptable.
- H. Cabinet:
  - Outdoor unit cabinet shall be made of minimum 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours.
  - 2. The front panels of the outdoor units shall be removable type for access to internal components.
  - 3. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.

#### PROJECT NO. 18-168.00 HARBORCHASE OF FARMINGTON HILLS, MICHIGAN HRA PERMIT SET

- I. Fan Assembly:
  - 1. Each outdoor unit frame shall be equipped with one or two direct-drive, variable speed axial flow fan(s) with variable speed, inverter-driven, Brushless Digitally Commutated (BLDC) motor(s) with a horizontal discharge.
  - 2. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
  - 3. The fan(s) motor shall be equipped with permanently lubricated bearings.
  - 4. The fan motor shall be variable speed with an operating speed range of 0-850 RPM cooling mode and heating mode.
  - 5. The fan shall have a guard to help prevent contact with moving parts.
- J. Operational Sound Levels:
  - Each single frame outdoor unit shall be rated with an operational sound pressure level not to exceed 57 dB(A) when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their equipment at other than tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available and the highest field selectable conditions shall not be allowed.
- K. Sensors:
  - 1. Each outdoor unit module shall have the following sensors:
    - a. Suction temperature sensor.
    - b. Discharge temperature sensor.
    - c. High pressure sensor.
    - d. Low pressure sensor.
    - e. Outdoor temperature sensor.
    - f. Outdoor unit heat exchanger temperature sensors.

## L. Electrical:

- 1. The outdoor unit electrical power shall be 208V / 1 Phase, and 60 hertz.
- 2. The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.

## 2.5 INDOOR, HEAT RECOVERY BOXES

- A. Description: Factory-assembled and tested complete with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
  - 1. Specifically designed for use in systems with simultaneous heating and cooling.
  - 2. Systems shall consist of one unit, or multiple units that are designed by the VRF system manufacturer for field connection to make a single refrigeration circuit that connects multiple indoor units.
- B. General
  - 1. Heat recovery unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
  - 2. Heat recovery unit casing shall be constructed with galvanized steel.
  - 3. Heat recovery unit shall require 208-230V/1-phase/60Hz power supply.
  - 4. Heat recovery Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems cooling and heating operation.

- 5. Heat recovery unit shall be engineered to work with a three pipe VRF system comprising of:
  - a. High Pressure Vapor Pipe
  - b. Low Pressure Vapor Pipe
  - c. Liquid Pipe
- 6. Heat recovery units' main 3 pipe connections shall be capable of series or parallel pipe configuration.
- 7. The quantity of heat recovery units that can be piped in series shall be limited to 16.
- 8. A single string of series piped heat recovery units shall be capable of serving any combination of styles of VRF indoor units with a combined nominal capacity of up to 240 MBh.
- 9. Heat recovery unit shall have 2, 3, 4, 6 or 8 ports, each port supporting one or more indoor units with a maximum connected capacity of 60 MBH.
- 10. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the heat recovery unit or in the system.
- 11. Each port shall be capable of connecting from 1 to 8 indoor units.
- 12. Connection to indoor units totaling greater than 60MBh nominal capacity shall be twinned to two adjacent ports of the heat recovery unit using a reverse Y-branch connector supplied by manufacturer.
- 13. Heat recovery unit shall be internally piped, wired, assembled and run tested at the factory.
- 14. Heat recovery unit shall be designed for installation in a conditioned environment per specifications.
- 15. Heat recovery unit shall employ a liquid bypass valve.
- 16. Heat recovery unit shall have (2) electronic expansion refrigerant valves per port.
- 17. Heat recovery unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching to minimize any change-over pressure related sounds.
- 18. Heat recovery unit shall employ an electronic expansion valve to ensure proper sub cooling of the refrigerant.
- 19. Heat recovery unit shall contain one double spiral sub-cooling heat exchanger per port.
- 20. Heat recovery unit shall not require a condensate drain or connection.
- 21. Heat recovery unit shall be internally factory insulated.
- 22. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat recovery unit to allow the servicing of heat recovery units, refrigerant circuit or the replacement of heat recovery unit without evacuating the balance of the piping system.

# 2.6 INDOOR UNITS

- A. Ceiling-Concealed, High-Static Ducted Units:
  - 1. General:
    - a. Unit shall be designed to be installed for indoor application.
    - b. Unit shall be designed to mount fully concealed above the finished ceiling.
    - c. Unit shall have opening to supply air from front horizontal and a dedicated rear horizontal return.
    - d. The supply air shall be flanged for field installed ductwork that shall not exceed the external static pressure limitation of the unit.
  - Indoor Unit: The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating electronic expansion valve, control circuit board and fan motors. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
  - 3. The indoor unit shall have the following functions:

- a. Self-diagnostic function.
- b. Auto addressing function.
- c. 3-minute time delay mechanism.
- d. Auto restart function.
- e. Auto changeover function (Heat recovery system only).
- f. Auto operation function.
- g. Auto clean function.
- h. Child lock function.
- i. Forced operation.
- j. Dual thermistor control.
- k. Sleep mode.
- I. External static pressure (ESP) control.
- m. Dual set point control.
- n. Filter life timer.
- o. External on/off control input.
- p. Wi-Fi compatible.
- q. Auto fan operation.
- r. Leak detection logic.
- 4. Casing / Panel:
  - a. Unit case shall be manufactured using galvanized steel plate.
  - b. The cold surfaces of the unit shall be covered internally with a coated polystyrene insulating material.
  - c. The cold surfaces of the unit shall be covered externally with sheet insulation made of Ethylene Propylene Diene Monomer (M-Class) (EPDM)
  - d. The external insulation shall be plenum rated and conform to ASTM Standard D-1418.
  - e. Unit shall be provided with hanger brackets designed to support the unit weight on four corners.
  - f. Hanger brackets shall have pre-punched holes designed to accept field supplied, all thread rod hangers.
- 5. Cabinet Assembly:
  - a. Unit shall have horizontal supply air discharge outlets and a return air inlet
  - b. Unit shall be equipped with factory installed temperature thermistors for:
    - 1) Return air
    - 2) Refrigerant entering coil
    - 3) Refrigerant leaving coil
  - c. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
  - d. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
- 6. Fan Assembly:
  - a. The unit shall have two direct drive Sirocco fans made of high strength ABS GP-2200 polymeric resin.
  - b. The fan impeller shall be statically and dynamically balanced.
  - c. The fans shall be mounted on a common shaft.
  - d. The fan motor is Brushless Digitally commutated (BLDC) with permanently lubricated and sealed ball bearings.
  - e. The fan motor shall include thermal, overcurrent and low RPM protection.
  - f. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
  - g. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of three pre-programed fan speeds, each setting is also adjustable by

field setting to compensate for a limited amount of additional resistance to airflow by adjusting the RPM of the fan motor.

- h. In cooling mode, the indoor fan shall have the following settings; Low, Med, High, and Auto.
- i. In heating mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.
- j. Each of the settings can be field adjusted from the factory setting (RPM/ESP).
- k. Unit shall be designed for high speed air volume against an external static pressure of up to 0.98" water gauge, model dependent.
- 7. Filter Assembly:
  - a. The return air inlet shall have a factory supplied removable, washable filter. MERV 13 filter rack is available as an option, model dependent.
  - b. The filter access shall be from the rear of the unit.
- 8. Coil Assembly:
  - a. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
  - b. The copper tubing shall have inner grooves to expand the refrigerant contact surface for high efficiency heat exchanger operation.
  - c. Unit shall have a minimum two to three row coil, 19-21 fins per inch.
  - d. Unit shall have a factory supplied condensate drain pan below the coil constructed of HIPS (high impact polystyrene resin).
  - e. Unit shall include an installed and wired condensate drain lift pump capable of providing minimum 27.5 inch lift from bottom surface of the unit. The unit drain pan is supplied with a secondary drain port/plug allowing the pan to be gravity drained and serviced.
  - f. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan, model dependent.
  - g. Unit shall have provision of 45° flare refrigerant pipe connections.
  - h. The coil shall be factory pressure tested at a minimum of 550 psig.
  - i. All refrigerant piping from outdoor unit to indoor unit shall be field insulated. Each pipe should be insulated separately. Thickness and heat transfer characteristics shall be determined by the design engineer and shall meet all code requirements.
- 9. Microprocessor Control:
  - a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system with or without the use of a wall mounted controller. The unit shall have a factory mounted return air thermistor for use as a space temperature control device. All operating parameters except scheduling shall be stored in non-volatile memory resident on the microprocessor. The microprocessor shall provide the following functions, self-diagnostics, auto re-start after a power failure and a test run mode.
  - b. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted, and shielded communication cable.
  - c. The unit controls shall operate the indoor unit using one of the five operating modes:
    - 1) Auto changeover (Heat Recovery System only)
    - 2) Heating
    - 3) Cooling
    - 4) Dry
    - 5) Fan only
  - d. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.
  - e. The unit shall be able to operate with the fan turned off during system cooling thermal off.
  - f. The unit shall be able to operate with a continuous fan setting.

- g. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.
- h. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable thermostat controller.
- 10. Electrical:
  - a. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz).
  - b. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage

# 2.7 CONTROLS

- A. General:
  - The manufacturer's controls shall be capable of supporting remote controllers, centralized controllers, an integrated web-based interface, graphical user workstation, and system integration to 3<sup>rd</sup> party Building Management Systems.
- B. Central Controller/Supervisor Interface
  - 1. General:
    - a. Central Controller(s) shall be capable of communicating with all VRF components (indoor units, outdoor units, proprietary ventilation equipment, etc.).
    - b. Central Controller shall have at least (2) Digital Outputs for control of 3<sup>rd</sup> party devices.
    - c. Central Controller shall be capable of controlling up to 128 VRF Indoor Units. If VRF Indoor Units exceed 128, additional Central Controllers shall be provided with one interface for the system.
    - d. Central Controller shall have the following functionality:
      - 1) Energy Reporting
      - 2) Visual floor plan navigation
      - 3) Alarming
      - 4) Email alarm notification
      - 5) Indoor unit grouping, monitoring, controlling and scheduling of the following functionality:
        - a) Set-point override
        - b) Set-point range limits
        - c) Unit vane swing control (where applicable)
        - d) Operational control
        - e) Mode control
        - f) Fan speed
      - 6) Equipment Scheduling shall be by time, day, month and year.
      - 7) Equipment run time limit
      - 8) Individual zone control lockout of any function
      - 9) Event logging indicating the following information:
        - a) Date & time of event
        - b) Unit(s) affected
        - c) Username
        - d) Adjustment details
        - e) Code (Control or Error)
      - 10) Password protection
    - e. Central controller shall have an intuitive graphical user interface either by touchscreen or web-based browser.
    - f. Central controller shall have the following settings:

- 1) Language
- 2) Date & time
- 3) Temperature, with option for Celsius or Fahrenheit.
- 4) Additional user creation
- 5) Static or DHCP IP Address settings
- 6) Adjustment of the IP Address, Subnet Mask and Gateway
- 7) BACnet ID, Network No. and port settings
- 2. Integration:
  - a. Central controller shall have the capability to integrate to a 3<sup>rd</sup> party BMS via the following protocols:
    - 1) BACnet IP®
    - 2) Fox Protocol®
    - 3) Lon (where applicable)
- 3. Electrical requirements
  - a. 24VAC or 12VDC
  - b. Minimum of 75 VA (AC) or 75 Watt (DC)
- C. VRF JACE Integration Device
  - 1. General:
    - a. VRF JACE Integration Device shall be a JACE 8000 or equivalent that includes the VRF Central Controller interface.
    - b. VRF JACE Integration Device shall include the VRF API.
    - c. VRF JACE Integration Device shall be a fully functioning JACE with embedded IOT, server platform for connecting multiple and diverse devices and subsystems.
    - d. VRF JACE Integration Device shall be capable of communicating with all VRF components (indoor units, outdoor units, proprietary ventilation equipment, etc.).
    - e. VRF JACE Integration Device shall have the following hardware features:
      - 1) Two Ethernet Ports 10/100 Mbps
      - 2) Two RS-485 ports with biasing switches
      - 3) One GB of RAM
      - 4) Four GB of Flash Total Storage/Two GB User Storage
      - 5) One Wi-Fi Antenna (Client or WAP)
      - 6) USB Flash Drive
      - 7) MicroSD Memory Card Employing Encrypted Safe Boot Technology
    - f. VRF JACE Integration Device shall have the following functionality:
      - 1) Energy Reporting
      - 2) Visual floor plan navigation
      - 3) Alarming
      - 4) Email alarm notification
      - 5) Indoor unit grouping, monitoring, controlling and scheduling of the following functionality:
        - a) Set-point override
        - b) Set-point range limits
        - c) Unit vane swing control (where applicable)
        - d) Operational control
        - e) Mode control
        - f) Fan speed
      - 6) Equipment Scheduling shall be by time, day, month and year.
      - 7) Equipment run time limit
      - 8) Individual zone control lockout of any function
      - 9) Event logging indicating the following information:

PROJECT NO. 18-168.00 HARBORCHASE OF FARMINGTON HILLS, MICHIGAN HRA PERMIT SET

- a) Date & time of event
- b) Unit(s) affected
- c) Username
- d) Adjustment details
- e) Code (Control or Error)
- 10) Password protection
- g. VRF JACE Integration Device shall have an intuitive graphical user interface either by touchscreen or web-based browser.
- h. VRF JACE Integration Device shall have the following settings:
  - 1) Language
  - 2) Date & time
  - 3) Temperature, with option for Celsius or Fahrenheit.
  - 4) Additional user creation
  - 5) Static or DHCP IP Address settings
  - 6) Adjustment of the IP Address, Subnet Mask and Gateway
  - 7) BACnet ID, Network No. and port settings
- 2. Integration:
  - a. VRF JACE Integration Device shall have the capability to integrate to a 3<sup>rd</sup> party BMS via the
    - following protocols: 1) BACnet IP®
      - 2) Fox Protocol®
      - a) Lon (where applicable)
- 3. Electrical requirements
  - a. 24VAC or 12VDC
  - a. 24 VAC OF 12 VDC b. Minimum of  $\frac{75}{4}$  (AC) or  $\frac{75}{4}$
  - b. Minimum of 75 VA (AC) or 75 Watt (DC)
- D. Local Zone Controllers
  - 1. General:
    - a. Local Zone Controllers shall be compatible with all VRF indoor units.
    - b. Local Zone Controllers shall have the functionality of sensing temperature at the controller, return air, or a combination of both
    - c. Local Zone Controllers must have BOTH manufacture's network connection AND RS8 BACnet MSTP connections for owner requested fail-over network control.
    - d. There are two (2) different types of local controllers; Simple and Premium
    - e. Simple Local Zone Controllers shall have the following functionality/control:
      - 1) Room Temperature Display
      - 2) Single Setpoint with Auto-Change-over
      - 3) Self-diagnostic function.
      - 4) Auto addressing function.
      - 5) 3-minute time delay mechanism.
      - 6) Auto restart function.
      - 7) Auto clean function.
      - 8) Child lock function.
      - 9) Forced operation.
      - 10) Dual thermistor control.
      - 11) Sleep mode.
      - 12) External static pressure (ESP) control.
      - 13) Dual set point control.
      - 14) Filter life timer.

- 15) External on/off control input.
- 16) Auto fan operation.
- 17) Leak detection logic.
- 18) Set-point override
- 19) Set-point display
- 20) Unit vane swing control (where applicable)
- 21) Operational control
- 22) Mode control
  - a) Auto changeover (Heat Recovery System only)
  - b) Heating
  - c) Cooling
  - d) Dry
  - e) Fan only
- 23) Fan speed
- 24) Group Control
  - a) Allow for up to (16) indoor units to be controlled from (1) zone controller
- 25) Auxiliary Heat control
  - a) VRF shall be configurable as 1<sup>st</sup> or 2<sup>nd</sup> stage heat.
- f. Premium Local Zone Controllers shall have the following functionality:
  - 1) Color Touch Screen Display with Screen Saver functionality
  - 2) Room Temperature Display
  - 3) Single Setpoint with Auto-Change-over
  - 4) 7-Day programmable schedule
    - a) 5 events per day
    - b) Control of on/off, Occ/UnOcc, Mode, Set-point and Fan Speed per event.
  - 5) Self-diagnostic function.
  - 6) Auto addressing function.
  - 7) 3-minute time delay mechanism.
  - 8) Auto restart function.
  - 9) Auto clean function.
  - 10) Child lock function.
  - 11) Forced operation.
  - 12) Dual thermistor control.
  - 13) Sleep mode.
  - 14) External static pressure (ESP) control.
  - 15) Dual set point control.
  - 16) External on/off control input.
  - 17) Auto fan operation.
  - 18) Leak detection logic.
  - 19) Set-point override
  - 20) Set-point display
  - 21) Humidity display (where applicable)
  - 22) Set-point range limits
  - 23) Unit vane swing control (where applicable)
  - 24) Operational control
  - 25) Mode control
    - a) Auto changeover (Heat Recovery System only)
    - b) Heating
    - c) Cooling

- d) Dry
- e) Fan only
- 26) Fan speed
- 27) Group Control
  - a) Allow for up to (16) indoor units to be controlled from (1) zone controller
- 28) Auxiliary Heat control
  - a) VRF shall be configurable as 1<sup>st</sup> or 2<sup>nd</sup> stage heat.
- 29) Scheduling
- 30) Customizable touch screen interface
  - a) Color adjustment
  - b) Hide/show any function or display
- 31) Date & time settings
- 32) Filter Alarm Status
- 33) BACnet® MS/TP integration capabilities
- 2. Electrical requirements:

a. Local Zone Controllers shall receive power from the Indoor Unit board.

- E. Handheld Wireless Remote Controller
  - 1. General:
    - a. Handheld Wireless Remote Controller shall be compatible with all VRF indoor units.
    - b. Handheld Wireless Remote Controller Shall communicate to VRF Indoor Units via an integral infrared Signal.
    - c. Handheld Wireless Remote Controller shall have the following functionality/control:
      - 1) Auto addressing function.
      - 2) 3-minute time delay mechanism.
      - 3) Child lock function.
      - 4) Sleep mode.
      - 5) External on/off control input.
      - 6) Set-point override
      - 7) Set-point display
      - 8) Unit vane swing control (where applicable)
      - 9) Operational control
      - 10) Mode control
        - a) Auto changeover (Heat Recovery System only)
        - b) Heating
        - c) Cooling
        - d) Dry
        - e) Fan only
      - 11) Fan speed
      - 12) Group Control
        - a) Allow for up to (16) indoor units to be controlled from (1) zone controller
  - 2. Power Requirements
    - a. Handheld Wireless Remote Controller shall be powered via and include AAA batteries.
- F. Room Temperature Sensor
  - 1. General:
    - a. The Room Temperature Sensor shall be compatible with all ceiling cassettes and ducted units.
    - b. The Room Temperature Sensor shall hook into and replace the return air thermistor.

- c. The Room Temperature Sensor shall be capable of working in conjunction with a Local Zone Controller.
- d. The Room Temperature Sensor shall be flush mounted and paintable.
- e. The Room Temperature Sensor shall be approximately 0.88 inch in diameter.
- f. The Room Temperature Sensor shall sense temperature and report back to the Central Controller.
- G. Dry Contact Kits
  - 1. Dry Contact Kits shall be compatible with all VRF Indoor Units.
  - 2. Dry Contact Kits shall include the following applications:
    - a. Simple Dry Contact
      - 1) Dry contact kit for 3<sup>rd</sup> party on/off control, operational status and/or error status.
      - 2) Simple Dry Contact shall include 24 VAC rated input.
      - 3) Simple Dry Contact shall be powered via the VRF Indoor Unit.
    - b. 3<sup>rd</sup> party thermostat Dry Contact
      - 1) Dry Contact kit for 3<sup>rd</sup> party thermostatic control.
      - 2) 3<sup>rd</sup> Party Thermostat Dry Contact shall 5-12 VDC and 24 VAC rated inputs.
      - 3) 3<sup>rd</sup> Party Thermostat Dry Contact shall connect direct to a 3<sup>rd</sup> party thermostat.
      - 4) 3<sup>rd</sup> Party Thermostat Dry Contact shall include logic for both a standard thermostat and heat pump style thermostat.
      - 5) 3<sup>rd</sup> Party Thermostat Dry Contact shall be powered via the VRF Indoor Unit.
    - c. Economizer Dry Contact
      - 1) Dry Contact kit enables VRF Indoor Unit to control an economizer.
      - 2) Economizer Dry Contact shall 5-12 VDC and 24 VAC rated inputs.
      - 3) Economizer Dry Contact shall be powered via the VRF Indoor Unit.
    - d. Auxiliary Heat Dry Contact
      - 1) Dry Contact Kit enables VRF Indoor Unit to control a 3<sup>rd</sup> party source of heat.
      - 2) Auxiliary Heat Dry Contact shall allow either source of heat to be 1<sup>st</sup> stage.
      - 3) Auxiliary Heat Dry Contact shall be powered via 24 VAC.
- H. Specialty Application Controllers:
  - 1. Input/Output Module:
    - a. Input/Output Module enables 3<sup>rd</sup> party devices to be controlled directly via the VRF Central Controller.
    - b. Input/Output Module shall include at least (3) Digital Outputs, (3) Digital Inputs, (4) Analog Outputs and (4) Universal Inputs.
    - c. Input/Output Module shall communicate via RS-485 Daisy Chain directly with the Central Controller.
    - d. Input/Output Module shall include the following types of inputs:
      - 1) NTC 10K
      - 2) PT100
      - 3) Ni1000
      - 4) DC Voltage (0-10V)
      - 5) DC Current (0-20mA)
    - e. Input/Output Module Analog Output's shall have a 0-10V voltage.
    - f. Input/Output Module Digital Output terminal's shall have a minimum rating of 2 amps at 30 VAC/DC.
    - g. Input/Output Module Shall be powered via 24 VAC.
  - 2. Power Distribution Indicator:
    - a. Power Distribution Indicator enables tracking of total energy consumption of individual VRF Indoor Units based on operation ratio.
    - b. Power Distribution Indicator shall be compatible with Central Controller/Supervisor Interface and/or VRF JACE Integration Device.
- c. Power Distribution Indicator shall be compatible with watt pulse meters.
- d. Power Distribution Indicator shall show current power use, total power consumption and accumulated power for a period of time.
- e. Power Distribution Indicator shall be capable of monitoring up to 128 VRF Indoor Units and 8 VRF Outdoor Units.

# 2.8 ACCESSORIES

- A. Provide any / all VRF system accessories as indicated on the Drawings and Schedules.
- 2.9 SYSTEM CONDENSATE DRAIN PIPING
  - A. Comply with requirements in Section XXXXX "Sanitary Drainage Piping" for system piping requirements.
- 2.10 SYSTEM HYDRONIC PIPING
  - A. Comply with requirements in Section XXXXX "Hydronic Piping" for system piping requirements.
- 2.11 SYSTEM REFRIGERANT PIPING
  - A. Comply with requirements in Section XXXXX "Refrigerant Piping" for system piping requirements.
  - B. The refrigeration piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer's published guidelines.
  - C. Divided-Flow Specialty Fittings: Where required by VRF system manufacturer for proper system operation, VRF system manufacturer shall furnish specialty fittings (Y-branch kits) with identification and instructions for proper installation by installer.

# PART 3 - EXECUTION

# 3.1 VRF PRE-INSTALLATION SUPPORT

A. General: The VRF manufacturer local representative's certified VRF field supervisor / project manager / technical support specialist shall hold a pre-installation coordination meeting with the mechanical contractor, electrical contractor, BAS contractor, and general contractor / construction manager to review the final approved VRF system design submittals, wiring requirements, piping requirements, insulation requirements, project-specific installation requirements, and all installation procedures. The VRF manufacturer local representative's certified VRF field supervisor / project manager / technical support specialist shall visit the project site once per week (minimum) throughout the duration of the VRF system(s) installation to review contractor compliance with all VRF manufacturer installation requirements.

# 3.2 EXAMINATION

- A. Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine products prior to installation. Reject products that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
- E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- G. Prepare written report, endorsed by installer, listing conditions detrimental to performance of the Work.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.
- 3.3 EQUIPMENT INSTALLATION GENERAL
  - A. Clearance:
    - 1. Maintain manufacturer's recommended clearances for service and maintenance.
    - 2. Maintain clearances required by all governing codes.
  - B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory-mounted.
    - 1. Loose components shall be installed by system installer under supervision of manufacturer's service representative.
- 3.4 INSTALLATION OF INDOOR UNITS
  - A. Install units to be level and plumb while providing a neat and finished appearance.
  - B. Unless otherwise required by VRF system manufacturer, support ceiling-mounted cassette units from structure above using galvanized steel threaded rods (minimum rod size of 3/8 inch), or approved steel aircraft-grade cabling system.
  - C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
  - D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replace damaged areas after units are installed.
  - E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
  - F. In rooms without ceilings, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

- G. For wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
- H. Provide and install electrical disconnect switches for each individual unit. Disconnects are to be provided by installer, not the VRF system manufacturer.
- I. Attachment: Install hardware for proper attachment to supported equipment.
- J. Grouting: Place grout under equipment supports and make bearing surface smooth.
- 3.5 INSTALLATION OF INDOOR / OUTDOOR CONDENSING UNITS
  - A. Install units to be level and plumb while providing a neat and finished appearance.
  - B. Install units on support structures as indicated on drawings.
  - C. Provide and install electrical disconnect switches for each individual unit. Disconnects are to be provided by installer, not the VRF system manufacturer.
  - D. Install multiple-module VRF condensing units in a master-slave arrangement, as identified by the VRF manufacturer's written instructions. VRF manufacturer's technical service advisor shall be present to supervise placement of multiple-module VRF condensing units.
  - E. Install all manufacturer-provided accessories such as hail guards, snow hoods, low ambient kits, hose kits, drain pan heaters, etc. in accordance with the VRF manufacturer's written instructions.
  - F. Pad-Mounted Installations: Install condensing units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations as specified elsewhere in the contract documents.
    - 1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
    - 2. Grouting: Place grout under equipment supports to make bearing surface smooth.
  - G. Roof-Mounted Installations: Install outdoor condensing units on minimum 18 inch high supports, specified elsewhere in the contract documents.
- 3.6 INSTALLATION OF REFRIGERANT PIPING
  - A. Install piping level and plumb while providing a neat and finished appearance.
  - B. Insulate all refrigerant piping insulation per manufacturer's recommendations and as specified elsewhere in the contract documents.
  - C. Divided-Flow Specialty Fittings: Install VRF manufacturer-provided divided-flow specialty fittings (Y-branch kits) as indicated by the manufacturer's installation instructions. Maintain installation orientation tolerances and distances between fittings as indicated by VRF manufacturer's written instructions.
  - D. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and

shall not interfere with that movement. Refer to manufacturer's installation guidelines for recommended refrigerant piping installation means and methods.

- E. Flaring: Install flared connections per the VRF manufacturer's recommendations.
- F. Brazing: Installer shall follow all VRF manufacturer's requirements for brazed installation of refrigerant piping. Failure to follow manufacturer's piping installation requirements will void equipment warranty. Requirements include, but are not limited to:
  - 1. Use a dry nitrogen purge operating at a minimum pressure of 3 psig and maintain steady flow.
  - 2. Use a 15% silver Phosphorus copper brazing alloy to avoid overheating and produce good flow.
  - 3. Protect isolation valves, electronic expansion valves, and other heat sensitive control components from excessive heat with a wet rag or heat barrier spray.
- G. Refrigeration Isolation Valves: Furnish and install refrigeration isolation valves at each heat recovery unit port and / or branch connection to each indoor unit.
  - 1. Refrigeration isolation valves shall be full-port ball valve type with Schrader service taps.
  - 2. Install insulation sleeve over each refrigeration isolation valve.
- H. Trapping: Provide traps as indicated by the VRF manufacturer's installation instructions. Review trapping requirements with VRF manufacturer's local representative prior to refrigerant piping installation.
- I. Field Piping Discrepancies / Revisions: Immediately bring any routing discrepancies or revisions to the attention of the VRF manufacturer's local representative for verification prior to installation. Revisions to piping layouts or configurations may affect refrigeration system pipe sizes.

# 3.7 INSTALLATION OF CONTROLS

- A. Install all control components and wiring in compliance with the Contract Documents, Division 26 Specifications, National Electrical Code (NEC) and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ) and the following:
  - 1. Complete VRF Controls System installation including all Local Zone Controllers, Central Controllers, VRF JACE Integration Devices, wiring and ancillary control devices.
  - 2. All control devices mounted outdoors shall be protected by a weather-shield from ambient elements in such a manner as to not impede design functionality and/or sensing.
  - 3. Installation shall be such that it provides sufficient clearance for system maintenance by maintaining sufficient access for equipment, device and/or component services, calibration, removal, repair or replacement.
  - 4. Penetrations through and mounting holes in the building exterior associated with the VRF Controls System shall be sealed and made water-tight.
  - 5. Installation, wiring and material shall be protected from damage by and during VRF Controls System installation.
- B. Install all control devices plumb and level.
- C. Install all control devices per manufacturer's recommendations.
- D. Communication Wiring:

- 1. General:
  - a. All intercommunicating wire shall be run in conduit or wire tray, reasonably distant from any high voltage wiring. The communication wiring shall never be run in the same conduit as high voltage wiring.
  - b.Exterior installation: Any communication wiring being installed outdoors shall be in UV rated conduit.
- 2. Central Control COMM Bus: Provide interconnecting 18/2 Stranded Shielded Twisted wiring between each Outdoor Unit and the Central Controller/Supervisor Interface VRF JACE Integration Device in a daisy chain formation. The polarity sensitive daisy chain network shall be grounded only at one end of the network for proper communication.
- 3. Indoor Unit COMM Bus: For each VRF system, provide 18/2 Stranded Shielded wiring between each Indoor Unit to the associated Outdoor Unit. The polarity sensitive daisy chain network shall be grounded only at the Outdoor Unit chassis ground for proper communication.
- 4. Remote Controller COMM Bus: For each VRF Indoor Unit that requires a Local Zone Controller, provide 18/3 Stranded wiring from the indoor board to the Local Zone Controller.
- 5. All communication wiring is to be provided by installer, not equipment manufacturer.
- E. Central Controller/ VRF JACE Integration Device/ Specialty Control Device Installation:
  - 1. General:
    - a. The Central Controller or other specialty controllers (except zone controllers/sensors) shall be installed in a NEMA 1 rated panel (Hoffman, Kele or equal), equipped with a power supply sized adequately to handle the electrical panel electrical requirements. The power supply shall have an integral breaker, (at least 1) 120VAC convenience outlet, on/off control, equipment overcurrent protection and high/low voltage separation. The panel and power supply are to be provided by installer, not the VRF system manufacturer.
    - b.All wiring interior to the panel shall be installed neat and tidy in wire mold chases.
    - c. The panel shall also include an industrial DIN rail mounted Ethernet network switch, equal to Contemporary Controls. The switch shall be connected to the building network and have enough ports to support all VRF Control Devices located inside the panel, plus an additional (2) ports for future expansion.
    - d. Each Panel shall be supplied with 120 VAC (from dedicated 20A CB by electrician) with battery backup UPS in 8x8 Hoffman or equal NEMA1 enclosure. UPS shall be hard wired with integral overload protection (fuse or CB) equal to Sola
    - e. Include Hard wired power supply with 120V convenience outlet, and overload/CB protection for 24VAC power equal to Functional Devices PSH100AWB10
    - f.
- 1) Green: Ground/Neutral
- 2) Red: Hot
- 3) Blue: Comm
- 4) Yellow: BI
- 5) Brown: BO
- 6) Magenta: AI
- 7) Pink: AO

- F. Panel Wiring
  - 1. All wiring in panel shall be trained in appropriately sized Panduit panel duct with cover around perimeter of panel.
  - 2. All panel wiring shall be performed in a UL panel shop with all field terminations to terminal strips for panel devices and controllers. Field wiring (other than comm and Ethernet) cannot be landed directly on controllers
- G. Field Wiring:
  - 1. All wiring shall conform to manufacture's IOM and be low capacitance (12pF/Ft) cable.
  - 2. All field wiring shall conform to NEC and all other applicable codes and standards
  - 3. Exposed control wiring in mechanical rooms, risers and concealed inaccessible locations shall be in EMT raceway.
  - 4. Concealed accessible control wiring shall be properly supported with bridle rings or other cable management parallel and perpendicular to building structure. Use plenum rated cable in plenum ceilings
  - 5. All control wiring shall be color coded and labeled to match panel schedule and control drawings per bedrock Standards.
  - 6. Wire tags/Labels shall be permanent, type written and easily readable equal to Brady Wrap-Around.
  - 7. Central Control COMM Bus: Provide interconnecting 18/2 Stranded Shielded Twisted wiring between each Outdoor Unit and the Central Controller/Supervisor Interface to VRF JACE Integration Device in a daisy chain formation. The polarity sensitive daisy chain network shall be grounded only at one end of the network per manufacturer IOM.

# 3.8

# 3.9 INSTALLATION OF HYDRONIC PIPING

- A. Install manufacturer-provided pre-fabricated piping specialties and control valves for each watersource condensing unit.
- B. Comply with requirements for hydronic piping and tubing as specified elsewhere in the contract documents.

# 3.10 ELECTRICAL INSTALLATION

- A. Comply with requirements indicated on the Drawings and in applicable electrical division specifications.
- B. To extent electrical power is required for VRF system equipment, components, and controls, and is not indicated on Drawings and addressed in Specifications, the design for such electrical power shall be delegated by the VRF system provider.
  - 1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no cost to the Owner.
- C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with installer.

- D. Provide and install electrical disconnect switches for each individual unit. All disconnect switches are to be provided by the installer.
- E. Do not mount field provided or installed disconnect switches directly to VRF condensing units. They must be mounted to separate supports.
- F. Comply with requirements for Low Voltage Electrical Power Conductors and Cables for wiring connections, specified elsewhere in the contract documents.
- G. Comply with requirements for Grounding and Bonding for Electrical Systems for grounding connections, specified elsewhere in the contract documents.
- H. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
  - 1. Nameplate shall be laminated phenolic layers of black with engraved letters. Letters at least <sup>1</sup>/<sub>2</sub> inch high.
  - 2. Locate nameplate or label where easily visible.
- I. Comply with requirements for Raceways and Boxes for Electrical Systems for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this section and as specified elsewhere in the contract documents.
  - 1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
  - 2. Flexible metal conduit shall not be used.
- J. Comply with TIA-595-D for pull-box sizing and length of conduit and number of bends between pull points.
- K. Install manufactured conduit sweeps and long-radius elbows if possible.
- L. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- M. Provide and install control circuit wiring between all VRF equipment per manufacturer wiring diagrams using an 18-guage, 2-conductor, twisted pair shielded cable to provide total integration of the system and VRF controllers.

# 3.11 IDENTIFICATION

A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified elsewhere in the contract documents.

# 3.12 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.
  - 1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

- B. Perform the following tests and inspections with the assistance of the VRF manufacturer's local technical service representative:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist. Refer to manufacturer's recommendations for leak test operating pressure and duration.
  - 3. Refrigerant Piping Evacuation: Evacuate each VRF refrigeration piping system as recommended by the VRF equipment manufacturer's recommendations.
    - a. Perform triple-evacuation method, alternating between vacuum and nitrogen purging based on total system micron levels.
    - b. Evacuate refrigeration system as required by VRF manufacturer's installation instructions. Each VRF system refrigerant piping network may not exceed the maximum micron level indicated by the VRF system manufacturer.
  - 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Operational test shall only be completed under supervision of VRF manufacturer's technical service representative.
  - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. System Refrigerant Charge:
  - 1. Using information collected from the refrigerant piping evacuation testing, installer shall consult variable refrigerant system manufacturer's representative to determine the correct system refrigerant charge.
    - a. Installer to provide VRF manufacturer's representative with corrected piping lengths for each run within the VRF system refrigeration piping network. Use manufacturer-provided piping diagrams for field length corrections.
  - 2. Installer shall charge system following VRF system manufacturer's written instructions.
  - 3. System refrigerant charging shall be witnessed by system manufacturer's representative at time of startup.
  - 4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.
- D. Products will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

# 3.13 STARTUP SERVICE

- A. Engage the VRF system manufacturer's local technical service advisor to perform system(s) startup service.
  - 1. Technical service advisor shall be a **local** factory-trained and -authorized service representative of VRF system manufacturer.
  - 2. Complete startup service of each separate system.
  - 3. Complete system startup service according to manufacturer's written instructions.
- B. Startup checks shall include, but are not limited to, the following:
  - 1. Check control communications of equipment and each operating component in system(s).
  - 2. Check each indoor unit's response to demand for cooling and heating.

- 3. Check each indoor unit's response to changes in airflow settings.
- 4. Check each indoor unit and outdoor unit for proper condensate removal.
- 5. Check sound levels of each indoor and outdoor unit for abnormalities.
- C. Installer shall accompany manufacturer's technical service advisor during startup and provide representative with requested documentation and technical support during startup service.
  - 1. Installer shall correct deficiencies found during startup service for reverification.
- D. System Operation Report:
  - 1. After completion of startup service, manufacturer's technical service advisor shall issue a report for each separate system.
  - 2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
  - 3. Manufacturer's representative shall electronically record not less than one hour of continuous operational run time data and submit with report for historical reference.
    - a. All available system operating parameters shall be included in the information submitted.

# 3.14 ADJUSTING

- A. Adjust the components to function smoothly, and lubricate as recommended by the manufacturer.
- B. Adjust initial temperature set points. Adjust initial airflow settings and discharge airflow patterns.
- C. Set field-adjustable switches and circuit breaker trip ranges according to VRF system manufacturer's written instructions, and as indicated.
- D. Occupancy Adjustments: When requested within 12 months from the date of Substantial Completion, provide on-site assistance in adjusting system(s) to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

# 3.15 PROTECTION

- A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.
- C. Protect equipment from electrical damage. Replace equipment affected by electrical damage and engage electrician to install safeties such as voltage regulators, power filters, and uninterruptable power supplies as required.
- D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove protective covering until all finish work is complete.
  - 1. Equipment shall not be started until all project finish work is complete. VRF systems shall not be operated to provide temporary heat, air conditioning, or ventilation at any time during project construction phase. Operation of VRF equipment prior to completion of all finish work will result in voided warranty of any / all affected VRF system(s) equipment.

# 3.16 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of VRF system installer who are certified by the VRF equipment manufacturer. Include minimum of four service visits for preventative maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be VRF manufacturer's authorized parts and supplies, available locally via the VRF system manufacturer's representative.

# 3.17 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for a minimum of two years.

# 3.18 DEMONSTRATION

- A. Engage the VRF system manufacturer's local employed training instructor to train Owner's maintenance personnel to adjust, operate, and maintain entire system(s).
- B. Instructor:
  - 1. Instructor shall be factory trained and certified by VRF system manufacturer with current training of the system(s), equipment, and controls that are installed.
  - 2. Instructor's credentials shall be submitted for review by Architect Commissioning Agent prior to scheduling Owner training.
- C. Schedule and Duration:
  - 1. Schedule training with Owner at least 10 business days before first training session.
  - 2. Training shall occur prior to Owner occupancy.
  - 3. Training shall be held at mutually agreed date and time during normal business hours.
- D. Location: Owner shall provide a suitable on-site location to host classroom training.
- E. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's names, signatures, phone numbers, and email addresses.
- F. Training Format: Individual training modules shall include classroom training followed by handson field demonstration and training.
- G. Training Materials: Provide training materials in electronic format to each attendee.
- H. Acceptance: Obtain Commissioning Agent or Owner written acceptance that training is complete and requirements indicated have been satisfied.

#### 3.19 CONTROLS COMMISSIONING

A. The VRF manufacturer's local rep shall include all necessary labor for the commissioning of the control system and verification of the integration to the Bedrock Supervisor.

- B. The VRF manufacturer's local rep shall provide complete verification of proper operation for all controls and integrity of the integration to the Bedrock Supervisor, including but not limited to:
  - 1. Point by point verification of the proper communication of values between the VRF Building Controller/JACE and the Bedrock Supervisor by comparing the user interfaces. Verify control point value change for random sampling of 10% and additional if any failures are found.
  - 2. Stability of room temperature set points. Field Verify random sampling of 10% with digital thermometer and additional if any failures are found.
  - 3. Commissioning by exception is not acceptable.

END OF SECTION

# SECTION 23 8126 – SPLIT SYSTEM AIR CONDITIONERS

# PART 1 - GENERAL

## 1.1 SUMMARY

- A. This Section includes split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components.
- B. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporatorfan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

# 1.2 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Diagram power, signal, and control wiring.

## 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- B. Warranty: Special warranty specified in this Section.

## 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 "Heating, Ventilating, and Air-Conditioning."

#### 1.6 COORDINATION

A. Coordinate size, location, and connection details with roof pads, equipment supports, and roof penetrations.

# 1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five years from date of Substantial Completion.

# PART 2 - PRODUCTS

# 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Dyken Mcquay
  - 2. LG Electronics
  - 3. Hitachi.
  - 4. Mitsubishi.

# 2.2 CONCEALED EVAPORATOR-FAN COMPONENTS

- A. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
  - 1. Insulation: Faced, glass-fiber duct liner.
  - 2. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1.
- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
- C. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
  - 1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
- D. Disposable Filters: 1 inch(25 mm) thick, in fiberboard framesWiring Terminations: Connect motor to chassis wiring with plug connection.

# 2.3 WALL-MOUNTING, EVAPORATOR-FAN COMPONENTS

- A. Cabinet: Enameled steel with removable panels on front and ends, and discharge drain pans with drain connection.
- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

- C. Fan: Direct drive, centrifugal fan.
- D. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
  - 1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
- E. Filters: Permanent, cleanable.

# 2.4 CEILING-MOUNTING, EVAPORATOR-FAN COMPONENTS

- A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
- C. Fan: Direct drive, centrifugal fan, with power-induced outside air, and integral condensate pump.
- D. Filters: Permanent, cleanable.

# 2.5 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

- A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
- D. Fan: Aluminum-propeller type, directly connected to motor.
- E. Motor: Permanently lubricated, with integral thermal-overload protection.
- F. Low Ambient Kit: Permits operation down to -20 deg F(-29 deg C).
- G. Mounting Base: Polyethylene.
- H. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."

# 2.6 ACCESSORIES

- A. Control equipment specified in Division 23 Sections "Instrumentation and Control for HVAC" and sequence of operations are on project controls drawing.
- B. Thermostat: Wall mounted hard wired, functioning to remotely control compressor and evaporator fan, with the following features:
  - 1. Compressor time delay.
  - 2. 24-hour time control of system stop and start.
  - 3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
  - 4. Fan-speed selection, including auto setting.
- C. Condensate Pump: Provide condensate mini-pump for condensate disposal.
- D. Safety: High condensate pan water level shutdown.
- E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
  - 1. Minimum Insulation Thickness: 1/2 inch(13 mm) thick.

# PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounting compressor-condenser components on polyethylene mounting base. Anchor units to base with removable, cadmium-plated fasteners.
- D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

# 3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
  - 1. Connect to condensate drain pans and extend to condensate pump and then to indicated disposal point. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- B. Install piping adjacent to unit to allow service and maintenance.

- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.
- 3.3 FIELD QUALITY CONTROL
  - A. Perform the following field tests and inspections and prepare test reports:
    - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
    - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - B. Remove and replace malfunctioning units and retest as specified above.

# 3.4 STARTUP SERVICE

- A. Perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.

#### 3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Division 01 Section "Demonstration and Training."

# END OF SECTION 23 8126

# SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

# 1.1 SUMMARY

- A. Section Includes:
  - 1. Electrical Scope of work
  - 2. Electrical equipment coordination and installation.
  - 3. Rough-in
  - 4. Common electrical installation requirements.

# 1.2 SCOPE OF WORK

- A. The scope of work is to include but not be limited to the following:
  - 1. Obtain all required electrical construction permits and inspections.
  - 2. File electrical service request with the Electric Utility for a new (upgraded, primary, secondary) electrical service.
  - 3. Provide cash allowance in bid for utility installation charges.
  - 4. Provide concrete pad and conduit for service transformer installation.
  - 5. Provide a 277/480 volt, 3 phase, 4 wire, distribution system for lighting and HVAC equipment.
  - 6. Provide a 120/208 volt, 3 phase, 4 wire, distribution system for convenience receptacles, small appliances and small motors.
  - 7. Refer to mechanical drawings, security, communications and access control drawings. Provide low voltage raceways (1/2" minimum) for all thermostats, controls and low voltage systems. No low voltage wiring of any type shall be visible in exposed ceiling areas.
  - 8. Provide complete electrical installation including all components, i.e. light fixtures, lamps, receptacles, conduit, wire, etc.
  - 9. Provide fire alarm system.
  - 10. Provide raceway system for sound system, clock/program system, and security system.
  - 11. Provide raceway system for telephone/data networking systems.
  - 12. Provide for Owner training by factory representatives in operation and maintenance of systems where specified.
  - 13. Submit documentation such as shop drawings, record documents, maintenance manuals, infrared scan results, systems test results, fire alarm system certification, etc. as specified.

# 1.3 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
  - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
  - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

- 3. To allow right of way for piping and conduit installed at required slope.
- 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate electrical systems, equipment and materials installation with other building components.
- C. Coordinate installation of electrical panelboard tubs, backboxes and concealed conduit and tubing with masonry/concrete work.
- D. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.
- E. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- G. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

# 1.4 INTERPRETATIONS

- A. It is the intent of these Drawings and Specifications to result in a complete electrical installation in complete accordance with applicable code and ordinances.
- B. Drawings are diagrammatic in character and do not necessarily indicate every required junction box, pull box, ell, etc. Items not specifically mentioned in the specification or noted on the Drawings, but which are necessary to make a complete working installation, shall be included.
- C. Drawings and Specifications are complementary. Whatever is called for in either is binding as though called for in both. The more stringent requirement shall govern.

# PART 2 - PRODUCTS

# PART 3 - EXECUTION

# 3.1 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 02 through 49 for rough-in requirements.

# 3.2 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1, Standard Practices for Good Workmanship in Electrical Construction.
- B. Arrange for chases, slots and openings in other building components during progress of construction, to allow for electrical installations.
- C. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
- D. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
- E. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wallmounting items.
- F. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- G. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- H. Right of Way: Give to piping systems installed at a required slope.

# 3.3 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

#### END OF SECTION 26 0500

# SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Building wires and cables rated 600 V and less.
  - 2. Connectors, splices, and terminations rated 600 V and less.
- 1.2 INFORMATIONAL SUBMITTALS
  - A. Field quality-control test reports.

# PART 2 - PRODUCTS

- 2.1 CONDUCTORS AND CABLES
  - A. Conductor Material: Copper complying with NEMA WC 70/ICEA S-95-658.
  - B. Conductor Insulation Types: Type THHN-2-THWN-2, Type XHHW-2 and Type SO
- 2.2 CONNECTORS AND SPLICES
  - A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

#### 2.3 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- 2.4 ALUMINUM CONDUCTORS (ALTERNATE)
  - A. Provide an alternate price to use aluminum alloy conductors for the incoming service feeders and distribution feeders sizes #3 AWG to 1000 Kcmil. Price shall include the aluminum conductors and the cost to increase the conduit size as required to satisfy the NEC.
  - B. Description:

# PROJECT NO. 18-168.00 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0519 - 2 HRA 10/24/2019 PERMIT SET

- 1. Aluminum alloy conductors shall be compact stranded conductors of a recognized Aluminum Association 8000 Series aluminum alloy conductor material (AA-8000 series alloy).
- 2. AA-8000 series alloy conductor must be Alcan Cable Stabiloy® or approved equal.
- 3. Compliance with the elongation requirement per Table 10.1 of UL Standard 1581 for stranded AA-8000 series aluminum alloy conductors shall be determined on wires taken from the conductor after stranding by manufacturer.
- C. Insulation :

1.

- 1. For use in raceways: Type XHHW-2, temperature rating 90° C.
- D. Connections for Conductors :
  - Using Mechanical Compression Type Connectors:
    - a. Connectors shall be dual rated (AL7CU or AL9CU) and Listed by UL for use with aluminum and copper conductors and sized to accept aluminum conductors of the ampacity specified.
    - b. The lugs shall be marked with wire size, die index, number and location of crimps and shall be suitably color-coded. Lug barrel shall be factory prefilled with a joint compound Listed by UL.
    - c. Using a suitable stripping tool, to avoid damage to the conductor, remove insulation from the required length of the conductor.
    - d. Wire brush the conductor.
    - e. Crimp the connection per the connector manufacturer's recommendation.
    - f. Wipe off any excess joint compound.
- *E.* Termination of Aluminum Conductor to Aluminum Bus:
  - 1. Prepare a mechanical compression connection.
  - 2. Hardware:
    - a. Bolts: Anodized alloy 2024-T4 and conforming to ANSI B18.2.1 and to ASTM B211 or B221 chemical and mechanical property limits.
    - b. Nuts: Aluminum alloy 6061-T6 or 6262-T9 and conforming to ANSI B18.2.2.
    - c. Washers: Flat aluminum alloy 2024-T4, Type A plain, standard wide series conforming to ANSI B27.2.
    - d. Lubricate and tighten the hardware as per the manufacturer's recommendations.
- F. Termination of Aluminum Conductor to Copper Bus:
  - 1. Prepare a mechanical compression connection.
  - 2. Hardware:
    - a. Bolts: Plated or galvanized medium carbon steel; heat treated, quenched and tempered equal to ASTM A-325 or SAE grade 5.
    - b. Nuts: Heavy semi-finished hexagon, conforming to ANSI B18.2.2, threads to be unified coarse series (UNC), class 2B.
    - c. Washers: Should be steel, Type A plain standard wide series conforming to ANSI B27.2.
    - d. Belleville conical spring washers: Shall be of hardened steel, cadmium plated or silicone bronze.
    - e. Lubricate and tighten the hardware as per the manufacturer's recommendations.
- G. Conduit Adjustment:
  - 1. It is the contractor's responsibility to adjust the conduit size in accordance with the NEC.

PART 3 - EXECUTION

- 3.1 CONDUCTOR AND INSULATION APPLICATIONS
  - A. Minimum conductor size for power wiring #12 AWG.
  - B. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.
  - C. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
  - D. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
  - E. Feeders Concealed in Concrete, below Slabs-on-Grade, and in Crawlspaces: Type THHN-2-THWN-2, single conductors in raceway.
  - F. Fire Pump Feeder: Provide a listed electrical circuit protective system with a minimum 2-hour fire rating.
  - G. Emergency Power Feeder: Provide a listed electrical circuit protective system with a minimum 2-hour fire rating.
  - H. Emergency Power Branch Circuits: Provide a listed electrical circuit protective system with a minimum 1hour fire rating, where indicated on plans.
  - I. Exposed Branch Circuits, including in Crawlspaces: Type THHN-2-THWN-2, single conductors in raceway.
  - J. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
  - K. Fixture Whips: Type MC cable may be used for light fixture whips only, with a maximum length of 6 feet.
  - L. Branch Circuits Concealed in Concrete and below Slabs-on-Grade: Type THHN-2-THWN-2, single conductors in raceway.
  - M. Underground Feeders and Branch Circuits: Type THHN-2-THWN-2, single conductors in raceway.
  - N. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wiremesh, strain relief device at terminations to suit application.
  - O. Fire Alarm Circuits: Type THHN-2-THWN-2, in raceway or Power-limited, fire-protective, signaling circuit cable where raceway is not specified.
  - P. Class 1 Control Circuits: Type THHN-2-THWN-2, in raceway.
  - Q. Class 2 Control Circuits: Type THHN-2-THWN-2, in raceway or Power-limited cable, concealed in building finishes where raceway is not specified.

# PROJECT NO. 18-168.00 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0519 - 4 HRA 10/24/2019 PERMIT SET

R. Dimming Control Circuits: Provide 600V rated cabling for 0-10V dimming circuits. Wiring to be installed in conduit where exposed. Install in accordance with the proper class 1 or class 2 circuit requirements as required by the lighting control system used.

# 3.2 INSTALLATION OF CONDUCTORS AND CABLES

- A. Where 120 volt, 20 amp, branch circuit wiring from panelboard to first outlet exceeds 100 feet in length, increase home-run wire size to #10 AWG.
- B. Where 277 volt, 20 amp, branch circuit wiring from panelboard to first light fixture exceeds 150 feet in length, increase home-run wire size to #10 AWG.
- C. Common neutral conductors **shall not** be used for convenience outlet or lighting branch circuits.
- D. Neutral conductors shall be clearly labeled at the panelboard with the circuit number of associated phase conductors.
- E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- H. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- I. Seal around cables penetrating fire-rated elements according to Division 07 Section "Penetration Firestopping."

# 3.3 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

# 3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

# PROJECT NO. 18-168.00 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0519 - 5 HRA 10/24/2019 PERMIT SET

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches(300 mm) of slack.

# 3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

# 3.6 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fireresistance rating of assembly according to Division 07 Section "Penetration Firestopping."

# 3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
  - 2. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
    - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- C. Remove and replace malfunctioning units and retest as specified above.

# END OF SECTION 26 0519

# SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes:
  - 1. Hangers and supports for electrical equipment and systems.
  - 2. Construction requirements for concrete bases.

# 1.2 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

# 1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

# 1.4 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code Steel."
- B. Comply with NFPA 70.

#### PART 2 - PRODUCTS

# 2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Allied Tube & Conduit.
    - b. Cooper B-Line, Inc.; a division of Cooper Industries.
    - c. ERICO International Corporation.

- d. GS Metals Corp.
- e. Thomas & Betts Corporation/ A Member of the ABB Group.
- f. Unistrut; Tyco International, Ltd.
- g. Wesanco, Inc.
- 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
- 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
- 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
- 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
  - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Hilti Inc.
      - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      - 3) MKT Fastening, LLC.
      - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
  - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
      - 2) Empire Tool and Manufacturing Co., Inc.
      - 3) Hilti Inc.
      - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

- 5) MKT Fastening, LLC.
- 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
- 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
- 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
- 6. Toggle Bolts: All-steel springhead type.
- 7. Hanger Rods: Threaded steel.

# 2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

# PART 3 - EXECUTION

# 3.1 APPLICATION

- A. Comply with NECA 1 for application of hangers and supports for electrical equipment and systems, except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch(6 mm) in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to trapeze member with clamps approved for application.
  - 2. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch(38mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.
- E. Provide independent support rings/shepherd hooks for any low voltage communications systems cabling. Cabling shall not rest on ceiling and shall be organized neatly on hooks. Cable shall not be visible in exposed ceiling spaces.

# 3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 for installation requirements, except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb(90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.
  - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Expansion anchor fasteners.
  - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches(100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches(100 mm) thick.
  - To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or spring-tension clamps.
  - 7. To Light Steel: Sheet metal screws.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

# 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

# 3.4 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and seismic criteria at Project.
- B. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

# PROJECT NO. 18-168.00 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0529 - 5 HRA 10/24/2019 PERMIT SET

- C. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 03 3000 "Cast-in-Place Concrete."
- D. Anchor equipment to concrete base.
  - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

# 3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils(0.05 mm).
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

# END OF SECTION 26 0529

# SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

## 1.1 SUMMARY

- A. Section Includes:
  - 1. Metal conduits, tubing, and fittings.
  - 2. Nonmetal conduits, tubing, and fittings.
  - 3. Metal wireways and auxiliary gutters.
  - 4. Nonmetal wireways and auxiliary gutters.
  - 5. Surface raceways.
  - 6. Boxes, enclosures, and cabinets.
  - 7. Handholes and boxes for exterior underground cabling.

#### 1.2 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.
- B. IMC: Intermediate metal conduit
- 1.3 ACTION SUBMITTALS
  - A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
  - B. LEED Submittals:
    - 1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
    - 2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
  - C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, hand holes and attachment details.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
  - 1. Structural members in paths of conduit groups with common supports.

2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

# 1.5 COORDINATION

A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

# PART 2 - PRODUCTS

# 2.1 METAL CONDUIT AND TUBING

- A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. GRC: Comply with ANSI C80.1 and UL 6.
- C. IMC: Comply with ANSI C80.6 and UL 1242.
- D. EMT: Comply with ANSI C80.3 and UL 797.
- E. FMC: Comply with UL 1; zinc-coated steel.
- F. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
  - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
  - 2. Fittings for EMT:
    - a. Material: Steel.
    - b. Type: Setscrew or compression.
  - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- H. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

# 2.2 NONMETALLIC CONDUIT AND TUBING

- A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ENT: Comply with NEMA TC 13 and UL 1653.

- C. RNC: Type EPC-40-PVC and EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. LFNC: Comply with UL 1660.
- E. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- F. Fittings for LFNC: Comply with UL 514B.
- G. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- H. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

# 2.3 PVC COATED RIGID METAL CONDUIT

- A. The PVC coated rigid metal conduit shall be hot dip galvanized inside and out. The interior galvanizing shall be listed per UL 6. The exterior galvanizing shall be listed per UL 6 as primary corrosion protection. Thread protectors shall be used on the exposed threads of the PVC coated conduit. PVC coated RMC steel conduit shall comply with UL 6, ANSI C80.1, and NEMA RN-1 standards without exception.
- B. The PVC coating, in compliance with NEMA RN-1, shall be nominal 40 mils in thickness continuous over the entire length of the conduit except at the threads, and be free of blisters, bubbles or pin- holes. PVC shall be UL listed as a primary corrosion protection.
- C. A urethane coating shall be uniformly and consistently applied to the interior of conduit. This internal coating shall be a nominal 2 mils thickness. All male threads on elbows and nipples shall be zinc coated using zinc rich paint.
- D. Coated couplings shall be used with coated conduit. The thickness of the coating on couplings shall be at least equal to the thickness of the coating on the conduit. Each coated coupling shall have a flexible PVC sleeve which extends from each end of the coupling and which will overlap the PVC coating on the conduit when the coupling has been installed on the conduit. The length of the sleeve extension(s) shall be at least equivalent to the nominal Trade Size for sizes 1/2" up through 1-1/2". For Trade Size 2" through 6", the length of the sleeve extension(s) shall be at least 2 inches. The PVC sleeve shall be a nominal thickness of 40 mils in thickness. The inside diameter of the overlapping sleeve shall be less than the outside diameter of the PVC-coated conduit.

# 2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1 or 3R as required.
- B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

- D. Wireway Covers: Hinged type, Screw-cover type, Flanged-and-gasketed type.
- Ε. Finish: Manufacturer's standard enamel finish.

#### 2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- Α. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- Β. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

#### 2.6 SURFACE RACEWAYS

- Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in Α. NFPA 70, by a gualified testing agency, and marked for intended location and application.
- Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard Β. prime coating and ivory finish coat.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - Thomas & Betts Corporation / A Member of the ABB Group. a.
    - Walker Systems, Inc.; Wiremold Company (The). b.
    - Wiremold Company (The); Electrical Sales Division. C.
- C. Surface Metal Raceways: Satin anodized extruded aluminum with snap-on covers.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Post Glover
    - Thomas & Betts Corporation / A Member of the ABB Group b.
    - Wiremold Company C.
- D. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC compound with matte texture ivorv color.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - Hellermann Tyton a.
    - Hubbell, Inc.; Wiring Device Division. b.
    - Lamson & Sessions; Carlon Electrical Products. C.
    - d. Mono-systems, Inc.
    - Panduit Corp. e.
    - Walker Systems, Inc.; Wiremold Company (The). f.
    - Wiremold Company (The); Electrical Sales Division. g.

E. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways. Provide concealed support clips or fasten raceway internally. Do not use external mounting straps.

# 2.7 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- E. Metal Floor Boxes:
  - 1. Material: Sheet-metal.
  - 2. Type: Fully adjustable.
  - 3. Shape: Rectangular.
  - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Nonmetallic Floor Boxes: Nonadjustable, round.
  - 1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb (32 kg).
  - 1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- K. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.
- L. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch

and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

- M. Telephone/Data Backboxes: Provide 2-gang, 3 ½ inch deep backboxes with single gang raised cover unless noted otherwise on plans.
- N. Low Voltage Boxes: 5-Square telecommunications outlet boxes (5 in. square x 2.875 deep w/ cable management) shall be used for all low voltage applications. 5-square box shall support 5e, 6, augmented 6, 7, and optical fiber cables. Low voltage boxes shall support integral cable management by allowing slack cable to be wound internally while maintaining minimum bend radius requirements. 5-square boxes shall also be used for all fire alarm applications.

# 2.8 FACTORY FINISHES

- A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard gray paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.
- 2.9 CABLE PATHWAY AND FIRESTOP DEVICE
  - A. Manufacturer:
    - 1. Specified Technologies, Inc., EZ-Path fire rated pathway.
    - 2. Wiremold, FlameStopper FS Series thru-wall fitting for fire walls.
  - B. Description: Through-the-wall 3" x 3" steel wiring channel or 4" EMT equipped with heat expanding intumescent fire stopping material.
  - C. Wiring channel shall be provided with steel wall plates allowing for single or multiple channels to be ganged together.
  - D. Wiring channel shall have an F rating equal to the rating of the barrier in which it is installed.
  - E. Wiring channel shall be capable of allowing a 0 to 100 percent visual fill of cable.
  - F. Wiring channel shall be tested in accordance with ASTM E 814 (ANSI/UL1479). Channel shall bear the UL classification marking.
  - G. Provide the quantity of devices needed to allow a cable pass cross section capacity of 50 percent of the adjacent cable tray cross section.

# 2.10 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
  - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
  - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
  - 1. Standard: Comply with SCTE 77.
  - 2. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
  - 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
  - 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
  - 5. Cover Legend: Molded lettering, "ELECTRIC".
  - 6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
  - 7. Wall Style: Flared wall assembly.

# PART 3 - EXECUTION

# 3.1 RACEWAY APPLICATION

- A. Outdoors:
  - 1. Exposed: Rigid steel or IMC.
  - 2. Concealed, Aboveground: Rigid steel or IMC.
  - 3. Underground: RNC Schedule 80.
  - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 5. Boxes and Enclosures: NEMA 250, Type 3R or 4.
- B. Indoors:
  - 1. Exposed in Unfinished Utility Spaces (mechanical rooms, electrical rooms and tunnels): EMT.
  - 2. Exposed in Finished Spaces: All conduit shall be concealed unless specifically indicated on plans.
  - 3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit or IMC.
  - 4. Concrete Floors: RNC.
  - 5. Concealed in Ceilings and Interior Walls and Partitions: EMT
  - 6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations.
  - 7. Damp or Wet Locations: Rigid steel conduit or IMC.
  - 8. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
    - a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.
- C. Minimum Raceway Size: 1/2-inch trade size(16mm),.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
  - 1. Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
### 3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this Article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Provide separate raceways for lighting, receptacle, and motor loads. Do not mix branch circuit wiring for these different loads in the same raceway.
- C. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- D. Complete raceway installation before starting conductor installation.
- E. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Install temporary closures to prevent foreign matter from entering raceways.
- G. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above finished slab.
- H. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- I. Make bends and offsets so ID is not reduced. Keep legs of bends in same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- J. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
  - 1. Install concealed raceways with a minimum of bends in shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
  - 2. Conduit and EMT may be surface mounted in Mechanical and Electrical Rooms except for wiring devices, light switches, low voltage devices or any other device shall be concealed in new wall.
  - 3. Surface mounted conduit or EMT may be used where specifically approved by Architect/Engineer. In such situations, the conduit, fastening devices, and junction boxes shall be painted to match the adjacent surface.
- K. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 2 inches (50 mm) of concrete cover.
  - 1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
  - 2. Space raceways laterally to prevent voids in concrete.
  - 3. Run conduit larger than 1-inch trade size (27mm) parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
  - 4. Change from nonmetallic tubing to rigid steel conduit, or IMC before rising above floor.
- L. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
  - 1. Run parallel or banked raceways together on common supports.

- 2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- M. Stub-ups to Above Recessed Ceilings:
  - 1. Use EMT, IMC, or RMC for raceways.
  - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- N. Join raceways with fittings designed and approved for that purpose and make joints tight.
  - 1. Use insulating bushings to protect conductors.
- O. Tighten set screws of threadless fittings with suitable tools.
- P. Terminations:
  - 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
  - 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
  - 3. Telephone, data and fiber optic cable conduits shall be provided with bushings on conduit ends.
- Q. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
- R. Color-Coding: Paint fire alarm system junction boxes and covers red.
- S. Raceways for Optical Fiber and Communications Cable: Install as follows:
  - 1. 3/4-Inch(19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet(15 m).
  - 2. 1-Inch(25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet(23 m).
  - 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- T. Telephone, data, AV, security, access control, fiber optic cable system, building control cabling, lighting control, 0-10V dimming control and any other low voltage systems cabling shall be installed in conduit in areas of exposed ceiling. In areas with accessible ceilings, the low voltage systems cables shall be neatly routed and independently supported with cable rings to the nearest cable tray, technology closet, conduit run or equipment connection. Systems to be in conduit in accessible ceiling spaces where required elsewhere in the specification or drawings.
- U. Telephone, data and fiber optic cable system conduit shall be provided with wide sweep bends.
- V. Telephone, data and fiber optic cable outlets shall be provided with a 1 inch conduit stubbed into accessible ceiling space unless noted otherwise on the drawings. Provide bushings on the ends of the conduit.

- W. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  - 2. Where otherwise required by NFPA 70.
- X. Expansion-Joint Fittings:
  - Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
  - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    - d. Attics: 135 deg F (75 deg C) temperature change.
  - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
  - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
  - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- Y. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches (150 mm) above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- Z. Flexible Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.
- AA. Flexible Connections to Lighting Fixtures:
  - 1. Above ceilings that are continuous to wall: Provide flexible conduit to all recessed lighting fixtures, maximum length as indicated. For fixtures mounted on grid ceilings, provide adequate length of flexible conduit to allow relocation of fixture on grid space in any lateral direction.

- 2. Above clouds or above suspended ceiling elements that are visible and exposed, Flexible Connections to Lighting Fixtures shall be limited to reduce sight of flexible conduit. <u>Flexible connections to light fixtures shall not be visible from standing on the floor or nearby landings or overlooks</u>. Minimize angle of visibility, run EMT as necessary and coordinate with trades to group systems to minimize drops. All drops to element/cloud to be EMT or IMC and shall not be flex.
- BB. Equipment Grounding Conductor: Install a green equipment grounding conductor in all flexible conduit and non-metallic (PVC) conduit.
- CC. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.
- DD. Recessed back-to-back boxes are not permitted in the same wall. Arrange boxes with at least 12 inches of horizontal spacing.
- EE. Recessed Boxes in Masonry Walls: Saw-cut opening for box in masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.
- FF. Locate boxes so that cover or plate will not span different building finishes.
- GG. Set floor boxes level and flush with finished floor surface.
- HH. Set floor boxes level. Trim after installation to fit flush with finished floor surface.
- II. Install hinged-cover enclosures and cabinets plumb. Support at each corner.
- JJ. Provide stainless steel cover plates on all abandoned boxes that remain from selective demolition.
- KK. Cable pathway and firestop device: Install in locations where indicated on the plans. Arrange singly or in gangs and mounted above accessible ceilings. Install the devices in strict accordance with the manufacturer's recommendations.

# 3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
  - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches(150 mm) in nominal diameter.
  - 2. Install backfill as specified in Division 31 Section "Earth Moving."
  - 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches(300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
  - 4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout length elbow.

- 5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
  - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches(75 mm) of concrete.
  - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches(1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
- 6. Underground Warning Tape: Comply with requirements in Section 26 0553 "Identification for Electrical Systems."

# 3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install handholes with bottom below frost line 42" below grade.
- E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

# 3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

# 3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

# 3.7 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

# PROJECT NO. 18-168.00 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0533 - 13 HRA 10/24/2019 PERMIT SET

# 3.8 CLEANING

A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 26 0533

## SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Conduit, ducts, and duct accessories for direct-buried duct banks.
  - 2. Handholes and boxes.
  - 3. Manholes.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For accessories for manholes, handholes, and boxes.
- B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
  - 1. Duct entry provisions, including locations and duct sizes.
  - 2. Reinforcement details.
  - 3. Frame and cover design and manhole frame support rings.
  - 4. Ladder details.
  - 5. Grounding details.
  - 6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
  - 7. Joint details.
- C. Shop Drawings for Factory-Fabricated Handholes and Boxes: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
  - 1. Duct entry provisions, including locations and duct sizes.
  - 2. Cover design.
  - 3. Grounding details.
  - 4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

# 1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

### 1.4 QUALITY ASSURANCE

- A. Comply with ANSI C2.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

## 2.1 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

# 2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ARNCO Corp.
  - 2. Beck Manufacturing.
  - 3. Cantex, Inc.
  - 4. CertainTeed Corp.; Pipe & Plastics Group.
  - 5. Condux International, Inc.
  - 6. ElecSys, Inc.
  - 7. Electri-Flex Company.
  - 8. IPEX Inc.
  - 9. Lamson & Sessions; Carlon Electrical Products.
  - 10. Manhattan/CDT; a division of Cable Design Technologies.
  - 11. Spiraduct/AFC Cable Systems, Inc.
- C. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
- D. Duct Accessories:
  - 1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
  - 2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."
  - 3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.
    - a. Color: Red dye added to concrete during batching.
    - b. Mark each plank with "ELECTRIC" in 2-inch- high, 3/8-inch- deep letters.

#### 2.3 HANDHOLES AND BOXES

A. Description: Comply with SCTE 77.

### PROJECT NO. 18-168.00 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0543 - 3 HRA 10/24/2019 PERMIT SET

- 1. Color: Gray.
- 2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
- 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 5. Cover Legend: Molded lettering, as indicated for each service.
- 6. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- 7. Handholes **12 inches wide by 24 inches long** and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
- B. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglassreinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Armorcast Products Company.
    - b. Carson Industries LLC.
    - c. Christy Concrete Products.
    - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
- C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of fiberglass.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Carson Industries LLC.
    - b. Christy Concrete Products.
    - c. Nordic Fiberglass, Inc.

# 2.4 PRECAST MANHOLES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Carder Concrete Products.
  - 2. Christy Concrete Products.
  - 3. Elmhurst-Chicago Stone Co.
  - 4. Oldcastle Precast Group.
  - 5. Riverton Concrete Products; a division of Cretex Companies, Inc.
  - 6. Utility Concrete Products, LLC.
  - 7. Utility Vault Co.
  - 8. Wausau Tile, Inc.

### PROJECT NO. 18-168.00 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0543 - 4 HRA 10/24/2019 PERMIT SET

- B. Comply with ASTM C 858 and with interlocking mating sections, complete with accessories, hardware, and features.
  - 1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
    - a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
    - b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
    - c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
- C. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.
- D. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

# 2.5 UTILITY STRUCTURE ACCESSORIES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Bilco Company (The).
  - 2. Campbell Foundry Company.
  - 3. Carder Concrete Products.
  - 4. Christy Concrete Products.
  - 5. East Jordan Iron Works, Inc.
  - 6. Elmhurst-Chicago Stone Co.
  - 7. McKinley Iron Works, Inc.
  - 8. Neenah Foundry Company.
  - 9. NewBasis.
  - 10. Oldcastle Precast Group.
  - 11. Osburn Associates, Inc.
  - 12. Pennsylvania Insert Corporation.
  - 13. Riverton Concrete Products; a division of Cretex Companies, Inc.
  - 14. Strongwell Corporation; Lenoir City Division.
  - 15. Underground Devices, Inc.
  - 16. Utility Concrete Products, LLC.
  - 17. Utility Vault Co.
  - 18. Wausau Tile, Inc.
- B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
  - 1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 26 inches.

- a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
- 2. Cover Legend: Cast in. Selected to suit system.
  - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
  - b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
  - c. Legend: "SIGNAL" for communications, data, and telephone duct systems.
- 3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
  - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.
- C. Manhole Sump: Depression cast in floor.
- D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- diameter eye, and 1by-4-inch bolt.
  - 1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.
- E. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- diameter eye, rated 2500-lbf minimum tension.
- F. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
  - 1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.
- G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
  - 1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.
- I. Cable Rack Assembly: Steel, hot-rolled galvanized, except insulators.
  - 1. Stanchions: T-section or channel; 2-1/4-inch nominal size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.
  - 2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
  - 3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

### PROJECT NO. 18-168.00 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0543 - 6 HRA 10/24/2019 PERMIT SET

- J. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- K. Fixed Manhole Ladders: Arranged for attachment to wall of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.
- L. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

# PART 3 - EXECUTION

# 3.1 EARTHWORK

- A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Sections "Turf and Grasses" and "Plants."
- D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

# 3.2 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations, unless otherwise indicated.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
  - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
  - 3. Grout end bells into structure walls from both sides to provide watertight entrances.

### PROJECT NO. 18-168.00 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0543 - 7 HRA 10/24/2019 PERMIT SET

- E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- G. Pulling Cord: Install 100-lbf- test nylon cord in ducts, including spares.
- H. Direct-Buried Duct Banks:
  - 1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
  - 2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
  - 3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches in nominal diameter.
  - 4. Install backfill as specified in Division 31 Section "Earth Moving."
  - 5. Concrete Cap: Install 4" concrete cap at a depth of 30 inches below grade. Cap to extend 6" past each side of overall duct bank width.
  - 6. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
  - 7. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
  - 8. Depth: Install top of duct bank at least 36 inches below finished grade, unless otherwise indicated.
  - 9. Set elevation of bottom of duct bank below the frost line.
  - 10. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
  - 11. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
    - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
  - 12. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of duct

bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

# 3.3 INSTALLATION OF CONCRETE MANHOLES

- A. Comply with ASTM C 891, unless otherwise indicated.
- B. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
- C. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- D. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
- E. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
- F. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
- G. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
- H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
- I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- J. Field-Installed Bolting Anchors: Do not drill deeper than 3-7/8 inches for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
- K. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

# 3.4 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch above finished grade.
- D. Install handholes and boxes with bottom below the frost line, below grade.

### PROJECT NO. 18-168.00 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0543 - 9 HRA 10/24/2019 PERMIT SET

- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

# 3.5 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

# 3.6 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
  - Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
  - 3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

# 3.7 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

# END OF SECTION 26 0543

### PROJECT NO. 18-168.00 SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0544 - 1 HRA 10/24/2019 PERMIT SET

## SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

- A. Section Includes:
  - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
  - 2. Sleeve-seal systems.
  - 3. Sleeve-seal fittings.
  - 4. Grout.
  - 5. Silicone sealants.
- B. Related Requirements:
  - 1. Division 07 Section "Penetration Firestopping" for penetration firestopping installed in fireresistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

# 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

# PART 2 - PRODUCTS

#### 2.1 SLEEVES

- A. Exterior Wall Sleeves:
  - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
  - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. Sleeves for Rectangular Openings:

- 1. Material: Galvanized sheet steel.
- 2. Minimum Metal Thickness:
  - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
  - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

# 2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Advance Products & Systems, Inc.
    - b. CALPICO, Inc.
    - c. Metraflex Company (The).
    - d. Pipeline Seal and Insulator, Inc.
    - e. Proco Products, Inc.
  - 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 3. Pressure Plates: Carbon steel.
  - 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

# 2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Presealed Systems.

# 2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

### PROJECT NO. 18-168.00 SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0544 - 3 HRA 10/24/2019 PERMIT SET

#### 2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
  - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
  - 2. Sealant shall have VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

# PART 3 - EXECUTION

# 3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
  - Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
  - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

### PROJECT NO. 18-168.00 SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 0544 - 4 HRA 10/24/2019 PERMIT SET

- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

# 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

# 3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

# END OF SECTION 26 0544

# SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Identification for raceways.
  - 2. Identification of power and control cables.
  - 3. Identification for conductors.
  - 4. Underground-line warning tape.
  - 5. Warning labels and signs.
  - 6. Instruction signs.
  - 7. Equipment identification labels.
  - 8. Miscellaneous identification products.

# 1.2 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

#### 1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

#### 1.4 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

## PART 2 - PRODUCTS

### 2.1 RACEWAY AND CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches(50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

# 2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemicalresistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches(50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

#### 2.3 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils(0.08 mm) thick by 1 to 2 inches(25 to 50 mm) wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemicalresistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend, machine printed by thermal transfer or equivalent process.

### 2.4 NAMEPLATES AND SIGNS

- A. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch(1.6 mm) thick for signs up to 20 sq. in.(129 sq. cm) and 1/8 inch(3.2 mm) thick for larger sizes.
  - 1. Engraved legend with black letters on white face.
  - 2. Punched or drilled for mechanical fasteners.
- B. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch(6.4-mm) grommets in corners for mounting.
- C. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch(1-mm) galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch(6.4-mm) grommets in corners for mounting.
- D. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

# 2.5 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
  - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
  - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
  - 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
  - 4. Not less than 6 inches wide by 4 mils thick(152 mm wide by 0.102 mm thick).
  - 5. Compounded for permanent direct-burial service.
  - 6. Embedded continuous metallic strip or core.
  - 7. Printed legend indicating type of underground line.
- B. Color and Printing:
  - 1. Comply with ANSI Z535.1 through ANSI Z535.5.
  - 2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
  - 3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

#### 2.6 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- C. Baked-Enamel Warning Signs:

- 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
- 2. 1/4-inch(6.4-mm) grommets in corners for mounting.
- 3. Nominal size, 7 by 10 inches(180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs:
  - 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch(1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
  - 2. 1/4-inch(6.4-mm) grommets in corners for mounting.
  - 3. Nominal size, 10 by 14 inches(250 by 360 mm).
- E. Warning label and sign shall include, but are not limited to, the following legends:
  - 1. Multiple Power Source Warning: "DANGER ELECTRICAL SHOCK HAZARD EQUIPMENT HAS MULTIPLE POWER SOURCES."
  - 2. Workspace Clearance Warning: "WARNING OSHA REGULATION AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES(915 MM)."

# 2.7 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch(10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
- B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch(10 mm).
- C. Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be 1 inch(25 mm).

# 2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

# PART 3 - EXECUTION

# 3.1 INSTALLATION

- A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.

- C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- E. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
- F. Circuits with More Than 600 V: Identify raceway and cable with "DANGER--HIGH VOLTAGE" in black letters 2 inches (51 mm) high, stenciled with paint at 10-foot (3-m) intervals over a continuous, painted orange background. Identify the following:
  - 1. Entire floor area directly above conduits running beneath and within 12 inches (305 mm) of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
  - 2. Wall surfaces directly external to conduits concealed within wall.
  - 3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.
  - 4. Entire surface of exposed conduits.
- G. Install painted identification according to manufacturer's written instructions and as follows:
  - 1. Clean surfaces of dust, loose material, and oily films before painting.
  - 2. Prime surfaces using type of primer specified for surface.
  - 3. Apply one intermediate and one finish coat of enamel.
- H. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, selfadhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.
- I. Circuit Identification on Device Plates.
  - 1. Identify circuits feeding receptacles with the designation of the panelboard and the circuit number in permanent marker on the back of each device cover plate.
  - 2. In mechanical, technology closets, electrical rooms and industrial type spaces, provide typed selfadhesive plastic labeling on outside of cover-plate to indicate the circuit number.
- J. Circuit Identification Labels on Boxes: Install labels externally.
  - 1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
  - 2. Concealed Boxes: Plasticized card-stock tags.
  - 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot(15-m) maximum intervals in straight runs, and at 25-foot(7.6-m) maximum intervals in congested areas.

L. Underground-Line Warning Tape: During backfilling of trenches, install continuous underground-line warning tape directly above line at 6 to 8 inches(150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches(400 mm) overall.

## 3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Install labels at 20-foot(6-m) maximum intervals.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
  - 1. Emergency Power.
  - 2. Power.
  - 3. UPS.
- C. Color-Coding of Secondary Phase Conductors: Use the following colors for service feeder and branchcircuit phase conductors:
  - 1. 208/120-V Conductors:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
    - d. Neutral: White.
    - e. Ground: Green.
  - 2. 480/277-V Conductors:
    - a. Phase A: Brown.
    - b. Phase B: Orange.
    - c. Phase C: Yellow.
    - d. Neutral: Slate/Gray.
    - e. Ground: Green.
  - 3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:
    - a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches(150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch-(25-mm-) wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
    - b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches(76 mm) from the terminal and spaced 3 inches(76 mm) apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.

- D. Provide labelling of each independent, conductors at 50' maximum centers, label at equipment and label at bus bars. Separate ground conductors routed concealed within conduit shall have conduit labels to identify the grounding conductor equipment or grounding/bonding location.
  - a. Indicate what equipment is fed or where the equipment is fed from on the label.
  - b. At service grounding bus bar, label "service grounding electrode conductor" at service entrance ground and label the equipment served by each equipment ground conductor.
- E. Apply identification to conductors as follows:
  - 1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
  - 2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
  - 3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.
- F. Apply warning, caution, and instruction signs as follows:
  - 1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
  - 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch-(9-mm-) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- H. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-(10-mm-) high letters for emergency instructions at equipment used for power transfer, load shedding and multiple services.
- I. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch-(13-mm-) high lettering on 1-1/2-inch-(38-mm-) high label; where two lines of text are required, use labels 2 inches(50 mm) high. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
  - 1. Panelboards, electrical cabinets, and enclosures.
  - 2. Access doors and panels for concealed electrical items.
  - 3. Electrical switchgear and switchboards.
  - 4. Electrical substations.
  - 5. Emergency system boxes and enclosures.
  - 6. Motor-control centers.
  - 7. Disconnect switches.
  - 8. Enclosed circuit breakers.
  - 9. Motor starters.

- 10. Push-button stations.
- 11. Boiler shut-offs.
- 12. Power transfer equipment.
- 13. Contactors.
- 14. Remote-controlled switches.
- 15. Dimmers.
- 16. Control devices.
- 17. Transformers.
- 18. Power-generating units.
- 19. Clock/program master equipment.
- 20. Call system master station.
- 21. Fire alarm control panel.
- 22. Security-monitoring master station or control panel.

### END OF SECTION 26 0553

# SECTION 26 0573.13 - SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.
- 1.2 ACTION SUBMITTALS
  - A. Product Data:
    - 1. For computer software program to be used for studies.
    - 2. Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.
      - a. Short-circuit study input data, including completed computer program input data sheets.
      - b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
        - Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
        - 2) Revised one-line diagram, reflecting field investigation results and results of shortcircuit study.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
  - 1. For Power Systems Analysis Software Developer.
  - 2. For Power System Analysis Specialist.
  - 3. For Field Adjusting Agency.
- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

# 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 1.5 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
  - 1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
  - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.
- F. Field Adjusting Agency Qualifications:
  - 1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
  - 2. A member company of NETA.
  - 3. Acceptable to authorities having jurisdiction.

# PART 2 - PRODUCTS

# 2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Comply with IEEE 399 and IEEE 551.
  - 1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

# 2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary of study findings.

- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Conductor types, sizes, and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor and generator designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
  - 6. Derating factors and environmental conditions.
  - 7. Any revisions to electrical equipment required by the study.
- D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.
- E. Protective Device Evaluation:
  - 1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
  - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated shortcircuit duties.
  - 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data:
  - 1. One-line diagram of system being studied.
  - 2. Power sources available.
  - 3. Manufacturer, model, and interrupting rating of protective devices.
  - 4. Conductors.
  - 5. Transformer data.
- G. Short-Circuit Study Output Reports:
  - 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. Equivalent impedance.
  - 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.

- b. Calculated symmetrical fault-current magnitude and angle.
- c. Fault-point X/R ratio.
- d. Calculated asymmetrical fault currents:
  - 1) Based on fault-point X/R ratio.
  - 2) Based on calculated symmetrical value multiplied by 1.6.
  - 3) Based on calculated symmetrical value multiplied by 2.7.
- 3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. No AC Decrement (NACD) ratio.
  - e. Equivalent impedance.
  - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
  - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

### PART 3 - EXECUTION

### 3.1 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the study.
- B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 01 7839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

#### 3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:
  - 1. To normal system low-voltage load buses where fault current is 10 kA or less.

- 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single lineto-ground fault at each equipment indicated on one-line diagram.
  - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- I. Include in the report identification of any protective device applied outside its capacity.

# END OF SECTION 26 0573.13

## SECTION 26 0573.16 - COORDINATION STUDIES

PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

### 1.2 ACTION SUBMITTALS

- A. Product Data:
  - 1. For computer software program to be used for studies.
  - 2. Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.
    - a. Coordination-study input data, including completed computer program input data sheets.
    - b. Study and equipment evaluation reports.
  - 3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
  - 1. For Power System Analysis Software Developer.
  - 2. For Power Systems Analysis Specialist.
  - 3. For Field Adjusting Agency.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.
- 1.4 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

### 1.5 QUALITY ASSURANCE

- A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
- D. Power System Analysis Software Qualifications:
  - 1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
  - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- F. Field Adjusting Agency Qualifications:
  - 1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
  - 2. A member company of NETA.
  - 3. Acceptable to authorities having jurisdiction.

# PART 2 - PRODUCTS

# 2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, timecurrent coordination plots.

# 2.2 COORDINATION STUDY REPORT CONTENTS

A. Executive summary of study findings.

- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Conductor types, sizes, and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor and generator designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
  - 6. Any revisions to electrical equipment required by the study.
  - 7. Study Input Data: As described in "Power System Data" Article.
    - Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0573.13 "Short-Circuit Studies."
- D. Protective Device Coordination Study:
  - 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
    - a. Phase and Ground Relays:
      - 1) Device tag.
      - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
      - 3) Recommendations on improved relaying systems, if applicable.
    - b. Circuit Breakers:
      - 1) Adjustable pickups and time delays (long time, short time, and ground).
      - 2) Adjustable time-current characteristic.
      - 3) Adjustable instantaneous pickup.
      - 4) Recommendations on improved trip systems, if applicable.
    - c. Fuses: Show current rating, voltage, and class.
- E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
  - 1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
  - 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
  - 3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
  - 4. Plot the following listed characteristic curves, as applicable:

- a. Power utility's overcurrent protective device.
- b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
- c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
- d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
- e. Ground-fault protective devices.
- f. The largest feeder circuit breaker in each motor-control center and panelboard.
- 5. Maintain selectivity for tripping currents caused by overloads.
- 6. Provide adequate time margins between device characteristics such that selective operation is achieved.
- 7. Comments and recommendations for system improvements.

# PART 3 - EXECUTION

# 3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
  - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

# 3.2 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the overcurrent protective device study.
  - 1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Architect's attention.
  - 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

# 3.3 COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
  - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
  - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Transformer Primary Overcurrent Protective Devices:
  - 1. Device shall not operate in response to the following:
    - a. Inrush current when first energized.
    - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  - 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- H. Motor Protection:
  - 1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
  - 2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
- Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- J. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.
- K. Include the ac fault-current decay from induction motors and apply to low- and medium-voltage, threephase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.
- L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single lineto-ground fault at each equipment indicated on one-line diagram.
  - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- M. Protective Device Evaluation:

- 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
- 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
- 3. Include in the report identification of any protective device applied outside its capacity.

## 3.4 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
  - 1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
  - 2. Determine load flow and voltage drop based on 80 percent of the design capacity of load buses.
  - 3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

## 3.5 MOTOR-STARTING STUDY

A. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect operation of other utilization equipment on system supplying the motor.

#### 3.6 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

#### 3.7 DEMONSTRATION

- A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:
  - 1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
  - 2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.

3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 26 0573.16

# SECTION 260574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

## 1.2 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Arc-flash study input data, including completed computer program input data sheets.
  - 2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report based on final approval of the distribution equipment submittals.

#### 1.3 CLOSEOUT SUBMITTALS

- A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
- B. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

#### 1.4 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

## PROJECT NO. 18-168.00 OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 260574 - 2 HRA 10/24/2019 PERMIT SET

- C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

# PART 2 - PRODUCTS

# 2.1 COMPUTER SOFTWARE DEVELOPERS

- A. <u>Software Developers</u>: Subject to compliance with requirements, available software developers offering software that may be used for the Work include, but are not limited to, the following:
  - 1. <u>ESA Inc</u>. (Easy Power)
  - 2. Operation Technology, Inc. (ETAP)
  - 3. <u>Power Analytics, Corporation</u>. (Paladin)
  - 4. <u>SKM Systems Analysis, Inc.</u>
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

# 2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Cable size and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor and generator designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article 3.3.
- E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

## PROJECT NO. 18-168.00 OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 260574 - 3 HRA 10/24/2019 PERMIT SET

- F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."
- G. Arc-Flash Study Output:
  - 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. No AC Decrement (NACD) ratio where applicable.
    - e. Equivalent impedance.
    - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- H. Incident Energy and Flash Protection Boundary Calculations:
  - 1. Arcing fault magnitude.
  - 2. Protective device clearing time.
  - 3. Duration of arc.
  - 4. Arc-flash boundary.
  - 5. Working distance.
  - 6. Incident energy.
  - 7. Hazard risk category.
  - 8. Recommendations for arc-flash energy reduction.
- I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

# 2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 4-by-6-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis. Arc flash labels to be compliant with latest version of NFPA 70E.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
  - 1. Location designation.
  - 2. Nominal voltage.
  - 3. Flash protection boundary.
  - 4. Site specific hazard risk category.
  - 5. Incident energy.
  - 6. Working distance.
  - 7. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

## 3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies:
  - Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
  - Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."
- C. Calculate maximum and minimum contributions of fault-current size.
  - 1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
  - 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- E. Include low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
- F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arcflash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:
  - 1. Fault contribution from induction motors should not be considered beyond three to five cycles.
- H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
  - 1. When the circuit breaker is in a separate enclosure.
  - 2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

# 3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
  - 1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
  - 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study.
  - 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  - 2. Obtain electrical power utility impedance at the service.
  - 3. Power sources and ties.
  - 4. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
  - 5. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
  - 6. Motor horsepower and NEMA MG 1 code letter designation.
  - 7. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

# 3.4 LABELING

- A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
  - 1. Motor-control center.
  - 2. Low-voltage switchboard.
  - 3. Switchgear.
  - 4. Medium-voltage switch.
  - 5. Control panel.

# 3.5 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

END OF SECTION 260574

# **SECTION 26 0913 - ELECTRICAL ENERGY METERING**

# PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section includes equipment and systems used to monitor and control electrical consumption:
  - 1. Multifunction meters.
  - 2. Raceways and boxes.
  - 3. Wires and cables.
  - 4. Identification.

# 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Product Data submittals for multi-function meter equipment.
  - 2. Include diagrams for power, signal, and control wiring.

## 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 1.4 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

# PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

- A. Solid state microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:
  - 1. Electrical meters that monitor, control, and connect to the data transmission network.
  - 2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a gualified testing agency, and marked for intended location and application.
- C. UL Compliance: Listed and labeled as complying with UL 61010-1.

# 2.2 PERFORMANCE REQUIREMENTS

- A. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.
- B. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.
  - 1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), KWD, power factor.
  - Communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.
- C. Backup Power Source:
  - 1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

# 2.3 MULTIFUNCTION ENERGY METERS

- A. Below is based on Schneider Electric/Squre D "ION 6200.EP2" "PM8000" and is suitable for monitoring measured values. Storage, alarms, and other accessories or functions are not part of this instrument and are not included in this description, but they may be available from manufacturer.
- B. Multifunction Energy Meter: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power and energy metering and monitoring; complying with UL 61010-1.
  - 1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
  - 2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.
- C. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
  - 1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of -20 to 70 degrees C and 5 to 95 percent relative humidity, noncondensing.
  - 2. Comply with IEC 60529 degree of protection code of IP65 for the front of the meter, and code of IP30 for the body.
- D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
- E. Accuracy:
  - 1. Comply with ANSI C12.20, Class 0.5.
  - 2. Neutral Current Measurement: Not more than 0.65 percent.
  - 3. Power Factor: 1.0 percent.
  - 4. Frequency: 0.1 percent.
  - 5. THD: 1.0 percent.

- 6. Waveform Sampling: 64 per cycle.
- F. Data Link:
  - 1. To be compatible with building automation system.
- G. Meter Physical Characteristics:
  - 1. Display: Backlit LCD with antiglare and scratch-resistant lens.
  - 2. Display of Metered Values:
    - a. One screen to show at least three user-selected values displayed at the same time. Selections available to display shall include the following:
      - 1) All meters.
      - 2) Measurements.
      - 3) THD.
      - 4) Energy.
      - 5) Demand.
      - 6) Minimum and maximum values.
      - 7) Power demand.
- H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on all voltage and current channels of the meter.
- I. Meters:
  - 1. Instantaneous, rms:
    - a. Current: Each phase, neutral and three-phase average.
    - b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
    - c. Active Power (kW): Each phase and three-phase total.
    - d. Reactive Power (kVAR): Each phase and three-phase total.
    - e. Apparent Power (kVA): Each phase and three-phase total.
    - f. Power Factor: Each phase and three-phase total.
  - 2. Energy:
    - a. Active Energy (kWh): Three-phase total.
  - 3. Demand, Derived from Instantaneous rms Meters:
    - a. Current: Present and maximum.
    - b. Active: Present and maximum.
    - c. Reactive: Present and maximum.
    - d. Apparent: Present and maximum.
  - 4. Power Quality Measurements:

- a. THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.
- J. I/O: Two optically isolated digital outputs for KY pulsing or control. Output signal characteristics shall be 150 mA at 200 V.
  - 1. KY Pulse: Generate standard KY pulses for a user-defined increment of metered active energy as follows:
    - a. User-defined pulse output, associated with kWh.
    - b. User-defined pulse output, associated with kVARh.
- K. Capacities and Characteristics:
  - 1. Power Supply: 120-V ac, 60 Hz or low voltage DC.
  - 2. Circuit Connections:
    - a. Voltage: Measurement autoranging, 60- to 400-V ac L-N. Meter impedance shall be 2megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
    - b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
    - c. Frequency: 45 to 65 Hz.
    - d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

# 2.4 RACEWAYS AND BOXES

A. Comply with requirements in Section 26 0533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

# 2.5 WIRES AND CABLES

- A. Electrical Power Wiring: Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
  - 1. Copper conductors are Type THHN/THWN-2.
- B. Control Wiring:
  - 1. Copper: Comply with requirements in Section 26 0523 "Control-Voltage Electrical Power Cables."
- C. Balanced Twisted-Pair Cable: 100-ohm, four-pair balanced twisted-pair cable, Category 6.
- D. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
  - 1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
  - 2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
  - 3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

PART 3 - EXECUTION

## 3.1 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

## 3.2 GROUNDING

- A. For data communication wiring, comply with NECA/BICSI 568.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."

## 3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections:
  - 1. Visually inspect balanced twisted-pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
  - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
  - 3. Test balanced twisted-pair cabling cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
    - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    - b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- C. Wiring and cabling will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

# END OF SECTION 26 0913

# **SECTION 26 0923 - LIGHTING CONTROL DEVICES**

PART 1 - GENERAL

# 1.1 SUMMARY

- A. Section Includes:
  - 1. Time switches.
  - 2. Photoelectric switches.
  - 3. Indoor occupancy switchbox-mounted occupancy and outdoor motion sensors.
  - 4. Emergency transfer devices.
- B. Related Requirements:
  - 1. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

# 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

# 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- 1.4 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data

#### 1.5 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

# PART 2 - PRODUCTS

# 2.1 TIME SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Douglas Lighting Controls

- 2. Intermatic, Inc.
- 3. Leviton Mfg. Company Inc.
- 4. Lighting Control and Design.
- 5. Lightolier Controls; a Genlyte Company.
- 6. Lithonia Lighting; Acuity Lighting Group, Inc.
- 7. Paragon Electric Co.; Invensys Climate Controls.
- 8. Square D; Schneider Electric.
- 9. TÖRK.
- 10. Touch-Plate, Inc.
- 11. Watt Stopper (The).
- B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
  - 1. Contact Configuration: DPST.
  - 2. Contact Rating: 30-A inductive or resistive, 240-V ac.
  - 3. Program: 8 on-off set points on a 24-hour schedule.
  - 4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
  - 5. Astronomic Time: Selected channels.
  - 6. Battery Backup: For schedules and time clock.
- C. Electromechanical-Dial Time Switches: Type complying with UL 917.
  - 1. Contact Configuration: DPST.
  - 2. Contact Rating: 30-A inductive or resistive, 240-V ac.
  - 3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
  - 4. Astronomic time dial.
  - 5. Eight-Day Program: Uniquely programmable for each weekday and holidays.
  - 6. Skip-a-day mode.
  - 7. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

# 2.2 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Douglas Lighting Controls
  - 2. Intermatic, Inc.
  - 3. Lighting Control and Design.
  - 4. Lithonia Lighting; Acuity Lighting Group, Inc.
  - 5. Novitas, Inc.
  - 6. Paragon Electric Co.; Invensys Climate Controls.
  - 7. Square D; Schneider Electric.
  - 8. TORK.
  - 9. Touch-Plate, Inc.
  - 10. Watt Stopper (The).

- B. Description: Solid state, with DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
  - 1. Light-Level Monitoring Range: 1.5 to 10 fc(16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
  - 2. Time Delay: 15-second minimum, to prevent false operation.
  - 3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
  - 4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-andswivel mounting accessories as required to direct sensor to the north sky exposure.
- C. Description: Solid state, with DPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.
  - 1. Light-Level Monitoring Range: 1.5 to 10 fc(16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
  - 2. Time Delay: 30-second minimum, to prevent false operation.
  - 3. Lightning Arrester: Air-gap type.
  - 4. Mounting: Twist lock complying with IEEE C136.10, with base.

# 2.3 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Douglas Lighting Controls
  - 2. Hubbell Lighting.
  - 3. Leviton Mfg. Company Inc.
  - 4. Lighting Control and Design.
  - 5. Lithonia Lighting; Acuity Lighting Group, Inc.
  - 6. Novitas, Inc.
  - 7. Sensor Switch, Inc.
  - 8. TORK.
  - 9. Watt Stopper (The).
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
  - 1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  - 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
  - Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
  - 4. Sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options.

- 5. Sensors shall be rated for their environment. Sensors installed in damp environment not limited to shower rooms, locker rooms, outdoor areas, shall be provided with high humidity option. High humidity option shall be available by the manufacturer when required.
- 6. Mounting:
  - a. Sensor: Suitable for mounting in any position on a standard outlet box.
  - b. Relay: Externally mounted through a 1/2-inch(13-mm) knockout in a standard electrical enclosure.
  - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
- 7. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
- 8. Bypass Switch: Override the on function in case of sensor failure.
- 9. Automatic Light-Level Sensor: Adjustable from 10 to 300 fc(21.5 to 2152 lx); keep lighting off when selected lighting level is present.
- C. Dual Technology Type: Ceiling mounting; detect occupancy by sensing a combination of passive infrared heat and ultrasonic technologies in area of coverage.
  - 1. Detector Sensitivity: Detect occurrences of 6-inch-(150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.(232 sq. cm).
  - 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft.(93 sq. m) when mounted on a 96-inch-(2440-mm-) high ceiling.

# 2.4 SWITCH-BOX OCCUPANCY SENSORS

- A. Manufacturers:
  - 1. Douglas Lighting Controls
  - 2. Hubbell Lighting Inc.
  - 3. Leviton Mfg. Company Inc.
  - 4. Lighting Control and Design.
  - 5. MYTECH Corporation.
  - 6. Novitas, Inc.
  - 7. Sensor Switch, Inc.
  - 8. TORK.
  - 9. Watt Stopper (The).
- B. Description: PIR type with integral power-switching contacts rated for 800 W at 120-V ac, suitable for incandescent light fixtures, fluorescent light fixtures with magnetic or electronic ballasts, or 1/6-hp motors; and rated for 1000 W at 277-V ac, suitable for incandescent light fixtures, fluorescent light fixtures with magnetic or electronic ballasts, or 1/3-hp motors, minimum.
  - 1. Sensor shall cover 1000 square feet for major motion and 300 square feet for minor motion.
  - 2. Sensor shall have an audible warning that beeps before lights turn off automatically. This feature shall have the option of being disabled.
  - 3. Include ground wire.
  - 4. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (215 to 2150 lx); keeps lighting off when selected lighting level is present.

5. Sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options.

# 2.5 DIGITAL OCCUPANCY SENSORS AND DIMMERS

- A. Manufacturers:
  - 1. nLIGHT by Sensor Switch, An Acuity Brands Company.
  - 2. Wattstopper.
- B. Digital System Occupancy Sensors
  - 1. Occupancy sensors system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
  - 2. All Sensors must be programmed for Vacancy Sensor operation for all rooms except for corridors and restrooms. Corridors and restrooms shall have the occupancy sensor turn the lights on when human activity is detected. The Digital Switch must be pressed for lighting to turn ON, and OFF. The sensor is for Automatic OFF ONLY.
  - Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state; thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.
  - 4. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional "dual" technology shall be used.
  - 5. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.
  - 6. All sensing technologies shall be <u>acoustically passive</u> meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.
  - 7. Sensors shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output. Sensors shall be capable of switching 120 / 277 / 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor. Relays shall be dry contacts.
  - 8. Sensors shall be available with one or two occupancy "poles", each of which provides a programmable time delay.
  - 9. Sensors shall be available in multiple lens options which are customized for specific applications.
  - 10. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
  - 11. All sensors shall have two RJ-45 ports.
  - 12. All sensors shall have the ability to detect when it is not receiving valid communication (via CAT-5 connections) and blink its LED in a pattern to visually indicate of a potential wiring issue
  - 13. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.

- 14. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.
- 15. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.
- 16. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.
- 17. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.
- 18. Wall switch sensors shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.
- 19. Wall switch sensors shall be available in four standard colors (Ivory, White, Light Almond, Gray)
- 20. Wall switch sensors shall be the following Sensor Switch model numbers, with device color and optional features as specified. See Drawings for Details and Part Numbers.
- 21. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.
- 22. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.
- 23. Sensors with dimming can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of Class 2 current (typically 40 or more ballasts).
- 24. Sensors shall be the following Sensor Switch model numbers, with device options as specified: See Drawings for Details and Part Numbers.
- C. Digital System Power (Relay) Packs
  - Power Pack shall incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay(s), shall have an optional 2<sup>nd</sup> relay, 0-10 VDC dimming output, or line voltage dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.
  - 2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.
  - 3. All devices shall have two RJ-45 ports.
  - 4. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.
  - 5. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
  - 6. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass
  - 7. through chase nipple into adjacent junction box without any exposure of wire leads.
  - 8. Power (Secondary) Packs shall be available that provide up to 16 Amp switching of all load types, and be rated for 400,000 cycles.
  - 9. Specific Secondary Packs shall be available that provide up to 5 Amps of switching as well as 0-10 VDC dimming of fluorescent ballasts.
  - Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).

- 11. Specific Secondary Packs shall be available that provide up to 5 Amps of switching of dual phase (208/240/480 VAC) lighting loads.
- 12. Specific Secondary Packs shall be available that require a manual switch signal (via a networked Wall Station) in order to close its relay.
- 13. When Required Specific Emergency Secondary Power Packs shall be available to provide switching up to 5 Amps at 120 or 277v and must hold a UL924 Listing.
- 14. Provide auxiliary relay for connection to building management system.
- 15. Power (Relay) Packs and Supplies shall be the following Sensor Switch model numbers: See Drawings for Details and Part Numbers.
- D. Digital System Wall Switches & Dimmers
  - 1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
  - 2. Devices shall be available with zero or one integrated Class 1 switching relay.
  - 3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
  - 4. All sensors shall have two RJ-45 ports.
  - 5. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
  - 6. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
  - 7. Devices with dimming control outputs can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of current (typically 40 or more ballasts).
  - 8. Devices with capacitive touch buttons shall provide audible user feedback with different sounds for on/off, raise/lower, start-up, and communication offline.
  - 9. Devices with mechanical push-buttons shall provide tactile and LED user feedback.
  - 10. Devices with mechanical push-buttons shall be made available with custom button labeling
  - 11. Devices with a single on button shall be capable of selecting all possible lighting combinations for a bi-level lighting zone such that the user confusion as to which of two buttons (as is present in multi-button scenarios) controls which load is eliminated.
  - 12. Wall switches & dimmers shall be the following Sensor Switch model numbers, with device options as specified: See Drawings for Details and Part Numbers.

# 2.6 OUTDOOR MOTION SENSORS (PIR)

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
  - 1. Bryant Electric; a Hubbell Company.
  - 2. Hubbell Lighting.
  - 3. Lighting Control and Design.
  - 4. Lithonia Lighting; Acuity Lighting Group, Inc.
  - 5. Paragon Electric Co.; Invensys Climate Controls.
  - 6. TORK.
  - 7. Watt Stopper (The).

- D. Performance Requirements: Suitable for operation in ambient temperatures ranging fromminus 40 to plus 54 deg C, rated as raintight according to UL 773A.
  - 1. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  - 2. Mounting:
    - a. Sensor: Suitable for mounting in any position on a standard outdoor junction box.
    - b. Relay: Internally mounted in a standard weatherproof electrical enclosure.
    - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
  - 3. Bypass Switch: Override the on function in case of sensor failure.
  - 4. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc(11 to 215 lx); keep lighting off during daylight hours.
- E. Detector Sensitivity: Detect occurrences of 6-inch-(150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.(232 sq. cm).
- F. Detection Coverage: Up to 35 feet(11 m), with a field of view of 180 degrees.
- G. Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.
- H. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
  - 1. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
  - 2. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

# 2.7 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Allen-Bradley/Rockwell Automation.
  - 2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
  - 3. Eaton Electrical Inc.; Cutler-Hammer Products.
  - 4. Douglas Lighting Controls
  - 5. GE Industrial Systems; Total Lighting Control.
  - 6. Grasslin Controls Corporation; a GE Industrial Systems Company.
  - 7. Hubbell Lighting.
  - 8. Lighting Control and Design.
  - 9. Lithonia Lighting; Acuity Lighting Group, Inc.
  - 10. Square D; Schneider Electric.
  - 11. TORK.
  - 12. Touch-Plate, Inc.
  - 13. Watt Stopper (The).

- B. Description: Electrically operated and mechanically held, combination type with fusible switch, complying with NEMA ICS 2 and UL 508.
  - 1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
  - 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
  - 3. Enclosure: Comply with NEMA 250.
  - 4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

# 2.8 EMERGENCY TRANSFER DEVICES

- A. Manufacturers:
  - 1. lota Engineering
  - 2. LVS, Inc.
  - 3. Philips Bodine
- B. Description: Generator (or central inverter) supplied egress lighting shall be provided by using a fixture equipped with an emergency transfer device, also called a generator transfer device.
  - 1. The device shall be capable of bypassing the wall switch or other lighting controls when the normal power fails to the fixture and transfer to emergency power.
  - 2. Device shall operate at 120 or 277 VAC, 60 Hz;
  - 3. Device shall comply with the NEC.
  - 4. The device shall be UL 924 Listed for installation inside, on top of or remote from the fixture.
  - 5. The device shall be warranted for a full five years from date of purchase.

# 2.9 EMERGENCY SHUNT RELAY

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Lighting Control and Design, Inc.
- B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
  - 1. Coil Rating: 277 V.

# 2.10 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No.14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

# PART 3 - EXECUTION

## 3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve at least 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.
- B. Install ceiling mounted sensors in the center of the lay-in ceiling tile when available.
- C. Install power packs above the accessible ceiling at the light switch location in room. If room does not have accessible ceiling and the adjacent corridor does, then install on corridor side. Install power pack in junction box to conceal the termination if installed on an exposed ceiling.
- D. Install according to manufacturer's recommendations.

## 3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

## 3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm). All low voltage and communication cabling shall be run in conduit, refer to Section 26 0533 – Raceways and Boxes for Electrical Systems.
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- D. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

## 3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
  - 1. Identify controlled circuits in lighting contactors.
  - 2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

## 3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
  - 2. Operational Test: Verify actuation of each sensor and adjust time delays.
- B. Remove and replace lighting control devices where test results indicate that they do not comply with specified requirements.
- C. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

#### 3.6 ADJUSTING

- A. Adjust time delay on each sensor to 15 minutes unless noted otherwise on plans.
- B. Coordinate light sensor level with owner to determine preferred operating range.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

#### END OF SECTION 26 0923

# SECTION 26 0943.23 - LIGHTING CONTROL SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

- A. Furnish and install a complete system for the control of lighting and other equipment as indicated on the plans, detailed in the manufacturer submittal and as further defined herein. Contractor is solely responsible to verify quantity, installation locations and wiring requirements for this project. Specific manufacturer's catalog numbers, when listed in this section are for reference only. It is the responsibility of the contractor to verify with lighting control manufacturer all catalog information and specific product acceptability.
- B. The system shall include but not be limited by the following list: Pre-wired, microprocessor controlled relay panels with electrically held, electronically latched relays panels controlled via a complete list of communication based accessories including digital switches, digital photocells, digital SmartBreaker panelboards, Digital Time Clock (DTC) and interface cards to dimming systems, building automation systems, thermostats, and other devices. The type of lighting control equipment and wiring specified in this section is covered by the description: Microprocessor Controlled Digital Relay Lighting Control system with RS 485 Bus communications. Requirements are indicated elsewhere in these specifications for work including, but not limited to, raceways and electrical boxes and fittings required for installation of control equipment and wiring.

# 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For each relay panel and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
  - 3. Detail wiring partition configuration, current, and voltage ratings.
  - 4. Short-circuit current rating of relays.
  - 5. Include diagrams for power, signal, and control wiring.

## 1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
  - 1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
  - 2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.
- B. Field quality-control reports.

- C. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- D. Sample warranty.
- 1.4 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.
  - B. Software and Firmware Operational Documentation:
    - 1. Software operating and upgrade manuals.
    - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
    - 3. Device address list.
    - 4. Printout of software application and graphic screens.
- 1.5 DELIVERY, STORAGE, AND HANDLING
  - A. Handle and prepare panels for installation according to NECA 407.

## 1.6 QUALITY ASSURANCE

- A. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with protocol described in IEC 60929, Annex E, for DALI lighting control devices, wiring, and computer hardware and software.
- E. Comply with NFPA 70.
- F. Lighting control relay panels shall be UL 916 Listed.
- G. Lighting control relay panels controlling emergency circuits shall be ETL listed to UL 924. Emergency source circuits controlled in normal operation by a relay panel shall fully comply with NEC 700-9(b). Electrical contractor to verify compliance.
- H. The lighting control system shall also be listed or approved by all national, state and local energy codes to include but not limited to California Title 24 and ASHRAE 90.1-2007.

# 1.7 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.
1. Match components and interconnections for optimum performance of lighting control functions.

- 2. Coordinate lighting controls with HVAC controls. Design display graphics showing building areas controlled; include the status of lighting controls in each area.
- 3. Coordinate lighting controls with that in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.
- B. Coordinate lighting control components specified in this Section with components specified in Division 26 Section "Panelboards."

# 1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Failure of software input/output to execute switching or dimming commands.
    - b. Failure of modular relays to operate under manual or software commands.
    - c. Damage of electronic components due to transient voltage surges.
  - 2. Warranty Period: Two years from date of Substantial Completion.
  - 3. Extended Warranty Period Failure Due to Transient Voltage Surges: Eight years.
  - 4. Extended Warranty Period for Electrically Held Relays: 10 years from date of Substantial Completion.

# 1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Electrically Held Relays: Equal to 10 percent of amount installed for each size indicated, but no fewer than 10 relays.
  - 2. Manual Switches: Provide 10 additional single stations and 5 additional two button stations.

# 1.10 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of the software.
  - 1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

# PART 2 - PRODUCTS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Crestron Electronics Inc.

- 2. Douglas Lighting Control
- 3. Intelligent Lighting Controls, Inc.
- 4. Leviton Mfg. Company Inc.
- 5. Lighting Control & Design, Inc.
- 6. Lightolier Controls; a Genlyte Company.
- 7. Lithonia Lighting; Acuity Lighting Group, Inc.
- 8. Lutron Electronics Company, Inc.
- 9. MicroLite Lighting Control Systems.
- 10. NexLight; Northport Engineering Group.
- 11. Starfield Controls, Inc.
- 12. Touch-Plate, Inc.
- 13. Watt Stopper (The).

# 2.2 SYSTEM REQUIREMENTS

- A. The lighting control system is a networked system that communicates via RS485. The system must be able to communicate with fully digital centralized relay panels, micro relay panels, smart breaker panels, digital switches, photocells, various interfaces and shall include all operational software. The intent of the specification is to integrate all lighting control into one system, except for areas controlled by a single motion sensor such as rooms with a single luminaire and emergency fixtures designed to operate 24/7. Distributed lighting control shall be provided using a networked micro relay panel. A centralized relay panel shall control corridors and site lighting. Lighting control system shall include all hardware and software. Software to be resident within the lighting control system. System shall provide local access to all programming functions at the master LCP and remote access to all programming functions via dial up modem and through any standard computer workstation running an industry standard internet browser. Lighting control system shall have server built into the master LCP that "serves" HTML pages to any authorize workstation. Desktop computers are not part of this section and will be provided by others. Non-networked, non-digital, non-server capable systems not acceptable.
- B. System software shall provide real time status of each relay, each zone and each group.
- C. Lighting control system shall be able to be monitored by and take commands from a remote PC. At any time, should the remote PC go off-line all system programming uploaded to the lighting control system shall continue to operate as intended. Systems requiring an on line PC or server for normal operation are not acceptable
- D. All devices shall be pre-addressed at the factory. Field addressing is not acceptable.
- E. All programs, schedules, time of day, etc, shall be held in non-volatile memory for a minimum of 10 years at power failure. At restoration of power, lighting control system shall implement programs required by current time and date.
- F. System shall be capable of flashing lights Off/On any relay or any zone prior to the lights being turned Off. The warning interval time between the flash and the final lights off signal shall be definable for each zone. Occupant shall be able to override any scheduled Off sweep using local wall switches within the occupied space. Occupant override time shall be locally and remotely programmable and not exceed 2-hours.
- G. The system shall be capable of implementing On commands, Off commands, Raise (dimming) commands, Lower (dimming) commands for any relay, group or zone by means of digital wall switches,

specification grade line voltage type wall switches, photocell, web based software or other devices connected to programmable inputs in a lighting control panel.

- H. The lighting control system shall provide the ability to control each relay and each relay group per this specifications requirement. All programming and scheduling shall be able to be done locally at the master LCP and remotely via dial up modem and via the Internet. Remote connection to the lighting control system shall provide real time control and real time feedback.
- I. System may consist of centralized relay panels, micro relay panels, smart breaker panels, digital switches, photocells and various digital interfaces. Verify exact components specified. Micro relay panels, smart breaker panels, centralized relay panels and digital switches shall communicate as one network via RS485. Micro relay panels, mounted in each local area, per plans shall control all lighting fixtures in that space, provide power to occupancy sensors and take input from daylight sensor and occupancy sensors. Micro relay panels shall be capable of taking inputs from standard, line voltage type switches and outputting up to 8 independent 0v to 10v dimming signals. All micro relay panels and all devices connected to micro relay panels (switches, photocells and occupancy sensors, etc) shall be wired per lighting control manufacturers instructions.
- J. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.

# 2.3 RELAY PANELS

- A. NEMA rated enclosure with screw cover or hinged door. Other NEMA types optional.
- B. 16 AWG steel barrier shall separate the high voltage and low voltage compartments of the panel and separate 120v, 277v and emergency circuits.
- C. LCP input power shall be capable of accepting 120v or 277v without rewiring
- D. Control electronics in the low voltage section shall be capable of driving 2 to 48, 30a, 18,000 SCCR rated latching relays, control any individual or group of relays, provide individual relay overrides, provide a master override for each panel, store all programming in non-volatile memory, after power is restored return system to current state, provide programmable blink warn timers for each relay and every zone, and be able to control relays that default to Open, Normally Open Latching (NOL) or relays that default to Closed, Normally Closed Latching (NCL).
- E. Lighting control system shall be digital and consist of a Master LCP, Slave LCPs, Micro LCPs with up to 8 individual relays, digital switches, digital interface cards and if required, SmartBreaker panelboards. All system components shall connect and be controlled via a single Category 5, 4 twisted pair cable with RJ45 connectors, providing real time two-way communication with each system component. Analog systems are not acceptable.
- F. The lighting control system is a networked system that communicates via RS485 and includes centralized relay panels, micro relay panels, digital switches, photocells, various interfaces and operational software. The intent of the specification is to integrate all lighting control into one system. Lighting control system shall include all hardware and software. Software to be resident within the lighting control system. System shall provide local access to all programming functions at the DTC and remote access to all

programming functions via dial up modem and through any standard computer workstation running an industry standard internet browser. Lighting control system shall have server built into the master LCP that "serves" HTML pages to any authorized workstation. Desktop computers are not part of this section and will be provided by others. Non-networked, non-digital system not acceptable.

## 2.4 MICRO RELAY PANELS

- A. Micro relay panels shall have up to 8-30a, 18,000 SCCR rated lighting relays and shall control all lighting in the designated area indicated on the plans and be networked to centralized relay panels, micro relay panels, smart breaker panels, digital switches, photocells, various interfaces. Each micro relay panel shall provide minimum 300ma at 12/24vdc for powering occupancy sensors. Micro relay panels that require a separate occupancy sensor power pack are not acceptable.
- B. Micro relay panel shall provide a minimum 4-programmable photocell inputs, a minimum 4-programmable occupancy sensor inputs and matrixed contact closure inputs. This requirement is to insure integration of entire lighting system into one networked, lighting control system.
- C. Micro relay panels shall be capable of outputting minimum 4 and up to 8 independent 0v to 10v dimming signals, one independent dimming signal at each of 8 relays. In order to maximize daylight harvesting and minimize disruption to occupants, each dimming output shall provide adjustment for baseline, start point, mid point, end point, trim, fade up rate, fade down rate, time delay and enable/disable masking. All photocell setting must be remotely accessible. Systems providing On, Off with Time Delay only, and system that do not provide remote access are not acceptable.

# 2.5 STANDARD OUTPUT RELAYS

- A. UL Listed 30 Amp, Latching, 18,000 SCCR, 277VAC Ballast and HID and 20 Amp Tungsten at 120 Vac.
- B. Relays shall be individually replaceable. Relay terminal blocks shall be capable of accepting two (2) #8AWG wires on both the line and the load side. Systems that do not allow for individual relay replacement or additions are not acceptable.
- C. Relays to be rated for 250,000 operations minimum at a full 30a lighting load, default to closed at normal power loss, Normally Closed Latching (NCL). All incandescent circuits shall be energized by use of a Normally Closed SoftStart™ (NCSS) relay rated at 100,000 operations at full 20a load. No exceptions.
- D. Optional relay types available shall include: Normally Open Latching (NOL) relay rated for 250,000 operations, a 600v 2-pole NO and NC and a Single Pole, Double Throw (SPDT) relay.

# 2.6 MANUAL SWITCHES AND PLATES

- A. Push-Button Switches: Modular, momentary-contact, low-voltage type.
  - 1. Match color specified in Division 26 Section "Wiring Devices."
  - 2. Integral green LED pilot light to indicate when circuit is on.
- B. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Division 26 Section "Wiring Devices."

- C. Wall Plates: Single and multigang plates as specified in Division 26 Section "Wiring Devices."
- D. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.
- E. All switches shall be digital and communicate via RS 485. Contact closure style switches, except as specified for connection to the micro relay panel matrixed contact closure inputs, shall not be acceptable. The programming for a digital switch will reside in the switch itself, via double EPROM memory. Any digital switch button function shall be able to be changed locally (at the DTC or a PC) or remotely, via modem, Internet or Ethernet.
- F. Digital low voltage switch shall be a device that sits on the lighting control system bus. Digital switch shall connect to the system bus using the same cable and connection method required for relay panels. System shall provide capability to locally and remotely program each individual switch button, monitor and change function of each button locally and remotely. Each button shall be capable of being programmed for On only, Off only, On/Off (toggle), Raise (Dim up) and Lower (Dim down). Switches shall also be capable of being disabled for specified times. Switches requiring low voltage control wires to be moved from one input terminal to another to accomplish these functions are not acceptable.
- G. Digital switches for high abuse areas (common areas, atrium, etc.) shall be vandal resistant, contain no moving parts, and be touch sensitive and available with up to three buttons in a single gang. Multi gang versions shall also be available. Touch pads shall be Stainless Steel and capable of handling both high abuse and wash down locations. High abuse switches shall connect to the lighting control system digital bus. Each high abuse switch touch button shall be able to be control any relay or any group in any panel or panels that is part of the lighting control system. Each touch button shall be able to be programmed for On, Off, Toggle or Maintain operation. All programming shall be done locally or remotely via dial up modem or web interface as described in other paragraphs of this section. High abuse switches shall be able to be enabled or disabled digitally. Each touch pad is to be identified as to function by an engraved label. Switches must be capable of handling electrostatic discharges of at least 30,000 volts (1cmspark) without any interruption or failure in operation.
- 2.7 DTC Digital Electronic Time Clock
  - A. A Digital Time Clock (DTC) shall control and program the entire lighting control system and supply all time functions and accept interface inputs.
  - B. DTC shall be capable of up to 32 schedules. Each schedule shall consist of one set of On and Off times per day for each day of the week and for each of two holiday lists. The schedules shall apply to any individual relay or group of relays.
  - C. The DTC shall be capable of controlling up to 126 digital devices on a single bus and capable of interfacing digitally with other individual busses using manufacturer supplied interface cards.
  - D. The DTC shall accept control locally using built in button prompts and use of a 8 line 21-letter display or from a computer or modem via an on-board RS 232 port. All commands shall be in plain English. Help pages shall display on the DTC screen.
  - E. The DTC shall be run from non-volatile memory so that all system programming and real time clock functions are maintained for a minimum of 15 years with loss of power.

- F. Pre-installed Unity<sup>™</sup> lighting control software shall provide via local or remote PC a visual representation of each device on the bus, show real time status and the ability to change the status of any individual device, relay or zone. System shall be capable of running optional Unity GX lighting control software, which shall provide for directly importing vector based graphics. No exceptions.
- G. Pre-Installed modem that allows for remote programming from any location using a PC. Modem to include all necessary software for local or remote control.
- H. DTC shall provide system wide timed overrides. Any relay, group or zone that is overridden On, before or after hours, shall automatically be swept Off by the DTC a maximum of 2 hours later.

# 2.8 PHOTOCELL

A. Photocells to be mounted in location indicated on the plans. Photocells used for exterior lights shall provide multiple trips point from 1 roof mounted unit. All trips points shall be able to be changed remotely via Internet or dial up modem. Photocells requiring manual trip point adjustment are not acceptable. Photocell used for interior lighting control shall have multiple settings such as start-point, mid-point, off-point, fade-up, fade-down, etc. All settings shall be remotely accessible and adjustable. Systems providing local adjustment only are not acceptable. Photocells to be certified to comply with the current energy code covering this project at time of submittal of plans for building permit.

# 2.9 INTERFACES

- A. For future expansion capability, system to have available all of the following interfaces:
  - 1. A dry contact input interface card that provides 14 programmable dry contact closure inputs. Use shielded cable to connect input devices to interface card.
  - 2. Interface card providing digital communication from one system bus to another system bus, allowing up to 12,000 devices to communicate.
  - 3. An interface card that allows the DTC to control up to 32 digital XCI brand thermostats. Programming of thermostats to be able to done locally (at the DTC or a PC) or remotely, via modem, Internet or Ethernet.
  - 4. A voice prompted telephone override interface module. Interface module shall accept up to 3 phone lines and allow up to 3 simultaneous phone calls. Voice prompted menu and up to 999 unique pass codes shall be standard with each interface module.
  - 5. Software pre-installed to run Unity GX Graphical Interface Software. Unity GX software shall provide via local or remote PC a visual representation of a specific area or the total area of the project. GX full graphic pages shall be designed to the owner's specifications. Owner to provide to manufacturer all necessary files and criteria
  - 6. Direct digital interface to SmartBreaker panelboards. Relay panel and SmartBreaker panelboard circuits shall appear on the system software as similar, yet distinct, items and maintain all functions and features of the system software.
  - 7. Direct digital interface to DMX 512 based systems. DMX interface shall provide 14 global commands, each of which can be modified locally or remotely using lighting controls manufacturer supplied software. DMX interface shall be integral to the system bus and shall connect and be controlled via a single Category 5, 4 twisted pair cable, providing real time response from the lighting control system to DMX commands.
  - 8. Direct digital interface to building automation systems using DDC protocols such as BACnet, Metasys (N2), LonWorks, ModBus, etc that accept on/off commands, time schedules and report

status of all relays in all panels in real time. Coordinate all interface requirements with the BAS provider. Interface cards shall "self populate" each individual relay and each group to the BAS. All BAS system programming required shall be the responsibility of the BAS system provider.

# 2.10 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 16 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- D. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5 for horizontal copper cable.

# PART 3 - EXECUTION

# 3.1 EXAMINATION

- A. Receive, inspect, handle, and store panels according to NECA 407.
- B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panels for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.2 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway except in unfinished spaces. Minimum conduit size shall be ½ inch.
  - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
  - 2. Comply with requirements for cable trays specified in Section 26 0536 "Cable Trays for Electrical Systems."
  - 3. Comply with requirements for raceways and boxes specified in Section 26 0533 "Raceways and Boxes for Electrical Systems."
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

## 3.3 PANEL INSTALLATION

- A. Comply with NECA 1.
- B. Install panels and accessories according to NECA 407.
- C. Mount panel cabinet plumb and rigid without distortion of box.
- D. Install filler plates in unused spaces.

## 3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 0553 "Identification for Electrical Systems."
- C. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.
- D. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- E. Provide a point-to-point wiring diagram for the entire lighting control system. Diagram must indicate exact mounting location of each system device. This accurate "as built" shall indicate the loads controlled by each relay and the identification number for that relay, placement of switches and location of photocell. Original to be given to owner, copies placed inside the door of each LCP.

## 3.5 INSTALLATION AND SET-UP

- A. Verify that conduit for line voltage wires enters panel in line voltage areas and conduit for low-voltage control wires enters panel on low-voltage areas. Refer to manufacturer's plans and approved shop drawings for location of line and low-voltage areas. It is the responsibility of the contractor to verify with lighting control manufacturer all catalog information and specific product acceptability.
- B. For approved line voltage type micro relay panel switches connected to matrixed inputs of the micro relay panel, furnish #18 AWG solid conductors. For all other digital switches provide wiring required by system manufacturer.
- C. For classroom digital switches provide wiring required by system manufacturer
- D. Contractor to test all low voltage cable for integrity and proper operation prior to turn over. Verify with system manufacturer all wiring and testing requirements.
- E. Before Substantial Completion, arrange and provide a one-day Owner instruction period to designated Owner personnel. Set-up, commissioning of the lighting control system, and Owner instruction includes:
  - 1. Confirmation of entire system operation and communication to each device.

- 2. Confirmation of operation of individual relays, switches, occupancy sensors and daylight sensors
- 3. Confirmation of system Programming, photocell settings, override settings, etc.
- 4. Provide training to cover installation, maintenance, troubleshooting, programming, and repair and operation of the lighting control system.
- F. Panels shall be located so that they are readily accessible and not exposed to physical damage.
- G. Panel locations shall be furnished with sufficient working space around panels to comply with the National Electrical Code.
- H. Panels shall be securely fastened to the mounting surface by at least 4 points.
- I. Unused openings in the cabinet shall be effectively closed.
- J. Cabinets shall be grounded as specified in the National Electrical Code.
- K. Lugs shall be suitable and listed for installation with the conductor being connected.
- L. Conductor lengths shall be maintained to a minimum within the wiring gutter space. Conductors shall be long enough to reach the terminal location in a manner that avoids strain on the connecting lugs.
- M. Maintain the required bending radius of conductors inside cabinets.
- N. Clean cabinets of foreign material such as cement, plaster and paint.
- O. Distribute and arrange conductors neatly in the wiring gutters.
- P. Follow the manufacturer's torque values to tighten lugs.
- Q. Before energizing the panelboard, the following steps shall be taken:
  - 1. Retighten connections to the manufacturer's torque specifications. Verify that required connections have been furnished.
  - 2. Remove shipping blocks from component devices and the panel interior.
  - 3. Remove debris from panelboard interior.
- R. Follow manufacturers' instructions for installation and all low voltage wiring.
- S. Service and Operation Manuals:
  - 1. Submit operation and service manuals. Complete manuals shall be bound in flexible binders and data shall be typewritten or drafted.
  - 2. Manuals shall include instructions necessary for proper operation and servicing of system and shall include complete wiring circuit diagrams of system, wiring destination schedules for circuits and replacement part numbers. Manuals shall include as-built cable Project site plot plans and floor plans indicating cables, both underground and in each building with conduit, and as-built coding used on cables. Programming forms of systems shall be submitted with complete information.
- T. Comply with energy code lighting control system "Acceptance Requirements". Acceptance tests are used to verify that lighting controls were installed and calibrated correctly. These tests may require that a responsible party certify that controls are installed and calibrated properly. This is the installing contractors responsibility. Verify requirements with building authority.

# 3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[with the assistance of a factory-authorized service representative]:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Acceptance Testing Preparation:
  - 1. Test continuity of each circuit.
- D. Lighting control panel will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

## 3.7 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. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.
- B. Provide factory-authorized personal for the following lighting control services:
  - 1. Provide programming time including feedback and site visit with Owner present to program the zones and times with owner input. Notify Engineer what date and time is set up for programming session for optional attendance.
  - 2. Provide lighting controls on-site commissioning and coordination with electrical contractor after initial programming and before building is occupied.
    - a. Provide at least 3 days for a building less than 30,000 square foot.
    - b. Provide at least 5 days for a building less than 200,000 square foot.
  - 3. Provide up to (8) hours of owner training with Owner present.
  - 4. Provide additional time after substation completion and within 30 days of owner Final Acceptance to make one-set of Owner requested changes.

## 3.8 ADJUSTING

A. Owner Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in programming scheduling, dimming and adjusting sensors and to assist
Owner's personnel in making program changes to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

B. Occupancy sensors shall be adjusted for seamless operation, contractor will have to move sensor and adjust settings at no charge due to faulty operation of the sensor due to location or settings for up to 12 months from date of Substantial Completion.

### 3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls and software training for PC-based control systems. Refer to Division 01 Section "Demonstration and Training."

### END OF SECTION 26 0943.23

## SECTION 26 2200 - LOW-VOLTAGE TRANSFORMERS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
  - 1. Distribution transformers.
  - 2. Buck-boost transformers.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each product indicated.
- B. Shop Drawings: Indicate dimensions and weights.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
  - 3. Include diagrams for power, signal, and control wiring.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Qualification Data: For testing agency.
- C. Field quality-control test reports.
- 1.4 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

### 1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

### 1.6 COORDINATION

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

## PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Corporation; Cutler-Hammer.
  - 2. General Electric Company.
  - 3. Magnetek Power Electronics Group.
  - 4. Micron Industries Corp.
  - 5. Siemens Energy & Automation, Inc.
  - 6. Sola/Hevi-Duty.
  - 7. Square D; Schneider Electric.

## 2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices, except for taps.
  - 1. Internal Coil Connections: Brazed or pressure type.
  - 2. Coil Material: Copper.

#### 2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Must be TP-1 energy efficient compliant.
- C. Must be DOE 2016 compliant.
- D. Cores: One leg per phase.
- E. Enclosure: Ventilated, dripproof, NEMA 250, Type 2.

- 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- G. Taps for Transformers Smaller Than 3 kVA: One 5 percent tap above normal full capacity.
- H. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
  - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
  - 2. Indicate value of K-factor on transformer nameplate.
- K. Wall Brackets: Manufacturer's standard brackets.
- L. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.
  - 1. Maximum acceptable sound level:
    - a. 9 KVA and less: 37dBA.
    - b. 30 to 50 KVA: 42 dBA.
    - c. 51 to 150 KVA: 47 dBA.
    - d. 151 to 300 KVA: 52 dBA.
    - e. 301 to 500 KVA: 57 dBA.
    - f. 501 to 750 KVA: 59 dBA.
    - g. 751 to 1000 KVA: 61 dBA.

#### 2.4 BUCK-BOOST TRANSFORMERS

- A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.
- B. Enclosure: Ventilated, NEMA 250, Type 2.
- 2.5 CONTROL AND SIGNAL TRANSFORMERS
  - A. Description: Self-cooled, two-winding dry type, rated for continuous duty, complying with NEMA ST 1, and listed and labeled as complying with UL 506.

B. Ratings: Continuous duty. If rating is not indicated, provide at least 50 percent spare capacity above connected peak load.

### 2.6 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.
- B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

### 2.7 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 26 Section "Identification for Electrical Systems."

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls and floors for suitable mounting conditions where transformers will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.2 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
- B. Install floor-mounting transformers level on concrete bases. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
- C. Install transformers larger than 75 KVA at least 12 inches away from walls or other obstructions that might prevent free air circulation through and around the transformer.
- D. Identify transformers and install warning signs according to Division 26 Section "Identification for Electrical Systems".

#### 3.3 CONNECTIONS

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

- B. Connect transformer units to conduit system panelboards, disconnect switches, or junction/pull boxes, using liquid-tight flexible conduit.
- C. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.4 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 5 percent. Submit recording and tap settings as test results.
- B. Adjust buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
- C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

### 3.5 FIELD QUALITY CONTROL

- A. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
  - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
  - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

#### 3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

## END OF SECTION 26 2200

### SECTION 26 2300 - LOW-VOLTAGE SWITCHGEAR

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. This Section includes metal-enclosed, low-voltage power circuit-breaker for the existing switchgear rated 1000 V and less for use in ac systems.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of circuit breaker, accessory, and component indicated.

### 1.3 INFORMATIONAL SUBMITTALS

- 1. Dimensioned Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- 2. Detailed description of equipment anchorage devices on which the certification is based.
- B. Field quality-control test reports.

#### 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 1.5 QUALITY ASSURANCE

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

## PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB Inc.
  - 2. Cutler-Hammer, Inc.; Eaton Corporation.
  - 3. General Electric Company.
  - 4. Siemens Energy & Automation, Inc.
  - 5. Square D; Schneider Electric.

## 2.2 COMPONENTS

- A. Instrument Transformers: Comply with IEEE C57.13.
  - 1. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
  - 2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.
- A. Multifunction Digital-Metering Monitor:
  - 1. Provide in accordance with Division 26 Section "Electrical Energy Metering".
  - 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
- B. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
  - 1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
  - 2. Conductors sized according to NFPA 70 for the duty required.

## 2.3 CIRCUIT BREAKERS

- A. Description: Comply with IEEE C37.13.
- B. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
- C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
  - 1. Normal Closing Speed: Independent of both control and operator.
  - 2. Slow Closing Speed: Optional with operator for inspection and adjustment.
  - 3. Stored-Energy Mechanism: Manually charged.
- D. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
  - 1. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
  - 2. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
  - 3. Field-adjustable, time-current characteristics.
  - 4. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
  - 5. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
  - 6. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I<sup>2</sup>t operation.
  - 7. Pickup Points: Five minimum, for instantaneous-trip functions.

- 8. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
  - a. Three-wire circuit or system.
  - b. Four-wire circuit or system.
  - c. Four-wire, double-ended substation.
- 9. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
- 10. Breakers or trip devices with continuous trip setting adjustable to 1200A or higher shall be provided with remote arc energy reduction for maintenance option with remote switch to be installed near door of electrical room (where indicated on Drawings). Remote switch shall not require manual change in circuit breaker or trip device settings.
- E. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.
- F. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
  - 1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
  - 2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
    - a. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
    - b. Disconnected Position: Primary and secondary devices and ground contact disengaged.
- G. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
- H. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
- I. Operating Handle: One for each circuit breaker capable of manual operation.
- J. Electric Close Button: One for each electrically operated circuit breaker.
- K. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
- L. Undervoltage Trip Devices: Adjustable time delay and pickup voltage.

M. Shunt-Trip Devices: Where indicated.

### 2.4 ACCESSORIES

- A. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
  - 1. Racking handle to manually move circuit breaker between connected and disconnected positions.
  - 2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
  - 3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
- B. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
- C. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
- D. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
- E. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

### 2.5 IDENTIFICATION

- A. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.
  - 1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
  - 2. Medium: Painted graphics, as selected by Architect.
  - 3. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.

## PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine elements and surfaces to receive switchgear for compliance with installation tolerances and other conditions affecting performance.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 26 0553 "Identification for Electrical Systems."
- B. Diagram and Instructions:
  - 1. Frame and mount under clear acrylic plastic on the front of switchgear.
    - a. Operating Instructions: Printed basic instructions for switchgear, including control and keyinterlock sequences and emergency procedures.
  - 2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

# 3.3 CONNECTIONS

- A. Install equipment grounding conductors for switchgear with ground continuity to main electrical ground bus.
- B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torquetightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

## 3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- B. Testing: After installing switchgear and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
  - 1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS. Certify compliance with test parameters.
    - a. Switchgear: Perform tests and inspections stated in NETA ATS, Section 7.1.
    - b. Circuit Breakers: Perform tests and inspections stated in NETA ATS, Section 7.6.
    - c. Instrument Transformers: Perform tests and inspections stated in NETA ATS, Section 7.10.
    - d. Metering and Instrumentation: Perform tests and inspections stated in NETA ATS, Section 7.11.
    - e. Ground-Fault Systems: Perform tests and inspections stated in NETA ATS, Section 7.14.
    - f. Surge Arresters: Perform tests and inspections stated in NETA ATS, Section 7.19.
    - g. Capacitors: Perform tests and inspections stated in NETA ATS, Section 7.20.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

- C. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
  - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
  - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

# 3.5 ADJUSTING

A. Set field-adjustable, protective-relay trip characteristics.

## 3.6 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

## 3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

## 3.8 STARTUP SERVICES

- A. Verify that switchgear is installed and connected according to the Contract Documents.
- B. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-topoint continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.
- C. Complete installation and startup checks according to manufacturer's written instructions.

## 3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.
  - 1. Train Owner's maintenance personnel on procedures and schedules for energizing and deenergizing, troubleshooting, servicing, and maintaining equipment and schedules.
  - 2. Review data in maintenance manuals. Refer to Division 01 Section "Closeout Procedures."
  - 3. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."
  - 4. Schedule training with Owner with at least seven days' advance notice.

END OF SECTION 26 2300

**SECTION 26 2413 - SWITCHBOARDS** 

PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Service and distribution switchboards rated 600 V and less.
  - 2. Transient voltage suppression devices.
  - 3. Disconnecting and overcurrent protective devices.
  - 4. Instrumentation.
  - 5. Control power.
  - 6. Accessory components and features.
  - 7. Identification.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each switchboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
  - 3. Include schematic and wiring diagrams for power, signal, and control wiring.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Field quality-control reports.

### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- 1.5 QUALITY ASSURANCE
  - A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Comply with NEMA PB 2.
- C. Comply with NFPA 70.
- D. Comply with UL 891.

#### 1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five years from date of Substantial Completion.

### 1.7 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Coordinate panels to be supplied with meter with Division 26 Section "Electrical Energy Metering".

### 1.8 EXTRA MATERIALS

- A. Spares: For the following:
  - 1. Potential transformer fuses.
  - 2. Control power fuses.
  - 3. Fuses for fused switches.
- B. Spare Indicating Lights: Six of each type installed.

#### PART 2 - PRODUCT

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB Inc.
  - 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 3. General Electric Company; GE Consumer & Industrial Electrical Distribution.
  - 4. Siemens Energy & Automation, Inc.
  - 5. Square D; a brand of Schneider Electric.

# 2.2 MANUFACTURED UNITS

A. Front-Connected, Front-Accessible Switchboard: Panel mounted main device, panel-mounted branches, and sections rear aligned.

### 2.3 FABRICATION AND FEATURES

- A. Enclosure Finish for Indoor Units: Factory-applied electrostatic powder coat in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- B. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard, if shown on Drawings.
- C. Screwed Front Panels: Allow access to circuit-breaker, metering, accessory, and blank compartments.
- D. Buses and Connections: Three phase, four wire, unless otherwise indicated. Include the following features:
  - 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with feeder fusedswitch/circuit-breaker line connections.
  - Ground Bus: 1/4-by-2-inch (6-by-50-mm) minimum size, drawn-temper copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
  - 3. Contact Surfaces of Buses: Silver plated.
  - 4. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
  - 5. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
  - 6. Neutral Buses: 100 percent of the ampacity of the phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus is braced.
- E. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of fused switch/circuit-breaker compartment.

## 2.4 SPD DEVICES

- A. Panelboard enclosure shall be designed to accommodate SPD within enclosure. SPD shall be factory mounted in panelboard connected directly to the bus without the use of a circuit breaker.
- B. Refer to Division 26 Section "Surge Protection for Low-Voltage Electrical Power Circuits."

## 2.5 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents with 20% additional capacity, 40,000 KA minimum.

- 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 2. Electronic Trip Unit Circuit Breakers (ET): RMS sensing; field-replaceable rating plug; with the following field-adjustable settings: 100% Sensing, 100% Rating.
  - a. Instantaneous trip.
  - b. Long- and short-time pickup levels.
  - c. Long- and short-time time adjustments.
  - d. Ground-fault pickup level, time delay, and I<sup>2</sup>t response,
  - e. Provide electronic trip breakers where indicated on Drawings.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
  - 1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
  - 2. Application Listing: Appropriate for application; Type HACR for heating, air-conditioning, and refrigerating equipment.
  - 3. Ground-Fault Protection: Where indicated on Drawings and where panel is over 1000A at 480V at the service entrance. Internally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  - 4. Shunt Trip: Where indicated on drawings. 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
  - 5. Zone-Selective Interlocking: Where indicated on drawings. Integral with electronic trip unit; for interlocking ground-fault protection function.
  - 6. Breakers with continuous trip setting adjustable to 1200A or higher shall be provided with remote arc energy reduction for maintenance option with remote switch to be installed near door of electrical room (where indicated on Drawings). Remote switch shall not require manual change in circuit breaker or trip device settings.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

## 2.6 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
  - 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
  - 2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
  - 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
- B. Multifunction Digital-Metering Monitor (where indicated on drawings):
  - 1. Provide in accordance with Division 26 Section "Electrical Energy Metering".
  - 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

#### 2.7 CONTROL POWER

- A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

### PART 3 - EXECUTION

### 3.1 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

### 3.2 EXAMINATION

- A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.3 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- B. Support switchboards on concrete bases, 4-inch(100-mm) nominal thickness.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

## 3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

## 3.5 CONNECTIONS

- A. Install equipment grounding connections for switchboards with ground continuity to main electrical ground bus.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

# 3.6 FIELD QUALITY CONTROL

- A. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
  - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
  - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

#### 3.7 ADJUSTING

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

#### 3.8 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

### 3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to properly use the switchboard mounted metering equipment. Refer to Division 01 Section "Demonstration and Training."

### END OF SECTION 26 2413

## **SECTION 26 2416 - PANELBOARDS**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each panelboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
  - 3. Detail bus configuration, current, and voltage ratings.
  - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
  - 5. Include evidence of NRTL listing for series rating of installed devices.
  - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 7. Include wiring diagrams for power, signal, and control wiring.
  - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Field quality-control reports.
- C. Panelboard schedules for installation in panelboards.

### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- 1.5 QUALITY ASSURANCE
  - A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.

#### 1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five years from date of Substantial Completion.

### 1.7 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.
- B. Prior to equipment installation, temporarily tape off distribution equipment rough-in and NEC clearance requirements in front of equipment and above equipment for other trades to observe. Label markings "ELECTRICAL CLEAR SPACE".

## PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
    - a. Eaton Corp.; Cutler-Hammer Products.
    - b. General Electric Co.; Electrical Distribution & Control Div.
    - c. Siemens Energy & Automation, Inc.
    - d. Square D Co.

### 2.2 FABRICATION AND FEATURES

- A. Enclosures: Flush- surface- mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.
  - 1. Outdoor Locations: NEMA 250, Type 3R.
  - 2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
- B. Cabinet heights shall not exceed the following without pre-approval:

(Subtract 12 inches from max cabinet height for MLO interiors)

NQ TYPE PANELBOARD MAIN	NUMBER OF SPACES	MAX CABINET HEIGHT
100A or less MB	30 spaces or less	44 inches
225A or less MB	54 spaces or less	50 inches
	72 spaces or less	56 inches
400A or less MB	42 spaces or less	62 inches
	72 spaces or less	74 inches

NF TYPE PANELBOARD MAIN	NUMBER OF SPACES	MAX CABINET HEIGHT
125A or less MB	30 spaces or less	44 inches
250A or less MB	54 spaces or less	56 inches
400A or less MB	42 spaces or less	68 inches
	66 spaces or less	86 inches

- C. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
- D. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
- E. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
- F. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.
- G. Breaker numbering: Provide adhesive labels with breaker numbering to be installed on each side of breakers to identify breaker number that corresponds to circuit directory.
- H. Bus: Hard-drawn copper, 98 percent conductivity.
- I. Main and Neutral Lugs: Mechanical type suitable for use with conductor material. Contractor is responsible for locating top or bottom feed main or lugs appropriate for top or bottom feeds.
- J. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
- K. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- L. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- M. Isolated Equipment Ground Bus: Where indicated on Drawings. Adequate for branch-circuit equipment ground conductors; insulated from box.
- N. Extra-Capacity Neutral Bus: Where indicated on Drawings. Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- O. Feed-through Lugs: Where indicated on Drawings. Mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

P. Provide handle clamps on all circuit breakers feeding fire alarm system components. Handle clamps shall lock the circuit breaker in the "ON" position.

# 2.3 PANELBOARD SHORT-CIRCUIT RATING

A. Fully rated to interrupt symmetrical short-circuit current available at terminals with 20% additional capacity, 10,000 KA minimum.

## 2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Circuit breaker interrupting rating shall be 10,000 RMS symmetrical amperes at 120/208/240 volts; 14,000 RMS symmetrical amperes at 277/480 volts unless noted otherwise on plans (add 20% to rating on plans).
- C. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

# 2.5 DISTRIBUTION PANELBOARDS

- A. Doors: Hinged, front mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.
- B. Main Overcurrent Protective Devices: Circuit breaker or Fused switch, as indicated on plans.
- C. Branch overcurrent protective devices shall be one of the following:
  - 1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
  - 2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
  - 3. Circuit breaker interrupting rating shall be 22,000 RMS symmetrical amperes at 120/208/240 volts; 25,000 RMS symmetrical amperes at 277/480 volts unless noted otherwise on plans.
  - 4. Fused switches.

### 2.6 SPD PANELBOARDS

- A. Refer to Division 26 Section "Surge Protection for Low-Voltage Electrical Power Circuits."
- B. Panelboard enclosure shall be designed to accommodate SPD within enclosure. SPD shall be factory mounted in panelboard connected directly to the bus without the use of a circuit breaker.

#### 2.7 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
  - 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

- 2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
- 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
- B. Multifunction Digital-Metering Monitor (where indicated on drawings):
  - 1. Provide in accordance with Division 26 Section "Electrical Energy Metering".
  - 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

## 2.8 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - 2. Electronic Trip Unit Circuit Breakers: (Where indicated on drawings) RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments.
    - d. Ground-fault pickup level, time delay, and I<sup>2</sup>t response.
  - 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  - 4. GFCI Circuit Breakers: Single- and two-pole configurations with 5 mA trip sensitivity.
  - 5. AFCI Circuit Breakers: Single- and two-pole configurations 20A trip, evaluated to UL 1699, Safety Standard for ARC-fault Circuit Interrupter.
- B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.
  - 1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
  - Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment; HID rated for high intensity discharge lighting.
  - 3. Ground-Fault Protection: Where indicated on Drawings. Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  - 4. Main breaker over 1000A at 480V on service entrance panel shall have ground fault protection.
  - 5. Breakers or trip devices with continuous trip setting adjustable to 1200A or higher shall be provided with remote arc energy reduction for maintenance option with remote switch to be installed near door of electrical room (where indicated on Drawings). Remote switch shall not require manual change in circuit breaker or trip device settings.
  - 6. Shunt Trip: Where indicated on Drawings. 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

### 2.9 CONTROLLERS

- A. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held general-purpose controller.
  - 1. Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
  - 2. Control-Power Source: 120-V branch circuit.

### PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Provide SWD rated circuit breakers for switching fluorescent lighting; HACR rated circuit breakers for heating, air conditioning and refrigeration equipment, and HID rated circuit breakers for high intensity discharge lighting.
- B. Install panelboards and accessories according to NEMA PB 1.1.
- C. Mounting Heights:
  - 1. Top of box 72 inches above finished floor, unless otherwise indicated.
  - 2. Bottom of box to be a minimum of 16 inches above finished floor.
- D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- E. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Use a computer or typewriter to create directory; handwritten directories are not acceptable. All circuit loads shall be visible without removing directory card.
- F. Distribution Panel Circuit Breaker/Switch Identification: Label each circuit breaker/switch unit with laminated-plastic nameplate mounted with corrosion-resistant screws or permanent adhesive.
- G. Install filler plates in unused spaces.
- H. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- I. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

# 3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

- 1. Panel label to have white letters on a black background. Provide the panel name, voltage and panel fed from on label.
- 2. Locate the label on the exterior of the panel door frame above the door unless otherwise indicated.
- 3. Locate the label on the panel interior side of the door when panel is recessed and located in a finished space.
- C. Clearance Space: In electrical equipment rooms, mechanical rooms or janitor's closets, provide floor marking tape to indicate NEC required clear space in front of panelboards and distribution equipment. Provide floor label that reads "ELECTRICAL CLEAR SPACE". Provide floor tape and label in accordance with 260553, "Identification for Electrical Systems."

# 3.3 CONNECTIONS

- A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.
- B. Where panelboards are located within 6 feet horizontally of any grounded structural building steel member, provide a bonding jumper between that steel member and the panelboard.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

## 3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
  - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:
  - 1. Measure as directed during period of normal system loading.
  - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.
  - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

- 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
- D. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
  - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
  - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

## 3.5 ADJUSTING

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

## 3.6 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 2416

**SECTION 26 2726 - WIRING DEVICES** 

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
  - 2. Wall-box motion sensors.
  - 3. Snap switches and wall-box dimmers.
  - 4. Communications outlets.
- B. See Division 27 Section "Communications Horizontal Cabling" for workstation outlets.
- 1.2 ADMINISTRATIVE REQUIREMENTS
- A. Coordination:
  - 1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
- 1.3 ACTION SUBMITTALS
- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- 1.4 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

## 1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

- 2.1 MANUFACTURERS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Wiring Devices:
    - a. Cooper Wiring Devices
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Mfg. Company Inc.
    - d. Pass & Seymour/Legrand; Wiring Devices Div.
  - 2. Wiring Devices for Hazardous (Classified) Locations:
    - a. Crouse-Hinds/Cooper Industries, Inc.; Arrow Hart Wiring Devices.
    - b. EGS/Appleton Electric Company.
    - c. Killark Electric Manufacturing Co./Hubbell Incorporated.
  - 3. Multi-outlet Assemblies:
    - a. The Wiremold Company.
  - 4. Poke-Through, Floor Service Outlets and Telephone/Power Poles:
    - a. Hubbell Incorporated; Wiring Device-Kellems.
    - b. Pass & Seymour/Legrand; Wiring Devices Div.
    - c. Square D/Groupe Schneider NA.
    - d. Wiremold Company (The).
    - e. Steel City/Thomas and Betts / A Member of the ABB Group.

### 2.2 RECEPTACLES

- A. Extra Heavy Duty/Industrial Grade Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, and UL 498.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere.
  - 2. Acceptable products:
    - a. Eaton 5362.
    - b. Hubbell HBL5362.
    - c. Leviton 5362.
    - d. P & S 5362A.
- B. Commercial Grade Straight-Blade Receptacles: Comply with NEMA WD 1, NEMA WD 6 and UL498.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere.
  - 2. Acceptable products:

- a. Eaton BR20.
- b. Hubbell \_\_.
- c. Leviton BR20.
- d. P & S BR20.
- C. Tamper Resistant Commercial Grade Straight-Blade Receptacles: Comply with NEMA WD 1, NEMA WD 6 and UL 498.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere.
  - 2. Acceptable products:
    - a. Eaton TRBR20
    - b. Hubbell BR20XXTR
    - c. Leviton TBR20
    - d. P & S TR5362A
- D. Tamper Resistant GFCI Specification Grade Straight-Blade Receptacles, Feed through type, Comply with NEMA WD 1, NEMA WD 6 and UL 498. Must meet UL 2003 standards for diagnostic indication of miswiring, increased surge immunity and improved corrosion resistance and resistance to false tripping.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere.
  - 2. Acceptable products:
    - a. Cooper TRSGR20 or equal.
- E. Hospital Grade Straight-Blade Receptacles. Comply with NEMA WD 1, NEMA WD 6 and UL498.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere.
  - 2. Acceptable products:
    - a. Eaton 8300.
    - b. Hubbell HBL8300.
    - c. Leviton 8300.
    - d. P & S 8300.
- F. Tamper Resistant Hospital Grade Straight-Blade Receptacles: Comply with NEMA WD 1, WD 6 and UL 498.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant."
  - 2. Acceptable products:
    - a. Eaton TR8300
    - b. Hubbell HBL8300-SG
    - c. Leviton 8300-SG
    - d. P& S TR63-H
- G. Tamper Resistant GFCI Hospital Grade Straight-Blade Receptacles: Feed-through type, comply with NEMA WD 6, UL498 and UL943. Must meet UL 2003 standards for diagnostic indication of miss-wiring, increased surge immunity, improved corrosion resistance and resistance to false tripping.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant."
  - 2. Acceptable products:
    - a. Eaton TRVGFH20.

- b. Hubbell GFR8300H\_TR.
- c. Levition 8300-HG-SG.
- d. P & S 2095-HGTRW.
- H. GFCI Specification Grade Straight-Blade Receptacles: Feed-through type, comply with NEMA WD 6, UL498 and UL943. Must meet UL 2003 standards for diagnostic indication of miss-wiring, increased surge immunity, improved corrosion resistance and resistance to false tripping.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere.
  - 2. Acceptable products:
    - a. Eaton XGF20
    - b. Hubbell GFR5352
    - c. Leviton 8899
    - d. P & S 2095
- I. Isolated Ground Straight-Blade Receptacles: Comply with NEMA WD 1, NEMA WD 6, UL498.
  - 1. NEMA 5-20R configuration, 125 volt, 20 ampere.
  - 2. Acceptable products:
    - a. Eaton IG-5362
    - b. Hubbell IG-5362
    - c. Leviton 5362-IG
    - d. P & S IG6300
- J. Industrial Heavy-Duty Pin and Sleeve Devices: Comply with IEC 309-1.
- K. Hazardous (Classified) Location Receptacles: Comply with NEMA FB 11.

# 2.3 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
  - 1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
  - 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

## 2.4 SWITCHES

- A. Single and Multi-pole Switches: Comply with UL20.
- B. Snap Switches: 20A, 120/277 volt, AC, heavy-duty grade, quiet type.
- C. Keyed Switches: 20A, 120/277 volt, AC, heavy-duty grade, quiet type.
  - 1. Provide two keys for each keyed switch installed on project. Turn-over keys to owner at time of Substantial Completion.

- D. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on/off switches and audible frequency and EMI/RFI filters.
  - 1. Wattage rating exceeds connected load by 30 percent minimum, except as otherwise indicated.
  - 2. Control: Continuously adjustable slider, toggle switch, or rotary knob; with single-pole or three-way switching to suit connections.
  - Incandescent Lamp Dimmers: Modular, 120 V, 60 Hz with continuously adjustable rotary knob, toggle switch, or slider; single pole with soft tap or other quiet switch; EMI/RFI filter to eliminate interference; and 5-inch(130-mm) wire connecting leads.

# 2.5 DEVICE PLATES

- A. Single and combination types to match corresponding wiring devices.
  - 1. Plate-Securing Screws: Metal with head color to match plate finish.
  - 2. Material for Finished Spaces: Smooth, high-impact thermoplastic. Color shall match device color.
  - 3. Material for Unfinished Spaces: Galvanized steel.. Color shall match wiring device color.
  - 4. Provide device plates for all power and data outlets.

# 2.6 WET LOCATION RECEPTACLE COVERS

- A. Wet Location Receptacle Covers: Receptacles located outdoors or those indicated as weatherproof shall be equipped with covers that maintain the NEMA 3R weatherproof integrity when attachment plug caps are inserted.
  - 1. Covers shall be die cast aluminum with powder coat finish, UL listed and comply with NEC.
  - 2. Covers shall be:
    - a. Tay Mac Corporation # MX3200
    - b. Red Dot #CKSUV

#### 2.7 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartmentation: Barrier separates power and signal compartments.
- C. Housing Material: Stamped steel suitable for concrete installation.
- D. Power Receptacle: NEMA WD 6, Configuration 5-20R, ivory finish, unless otherwise indicated.
- E. Signal Outlet: Blank cover with bushed cable opening, unless otherwise indicated.
- F. Finish Trim and Door: Hinged nylon carpet/tile insert door permitting passage of cords and cables while in closed position. Trim color selected by Architect.

### 2.8 POKE-THROUGH ASSEMBLIES

- A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
  - 1. Size: Selected to fit nominal 3 inch (75 mm) cored openings in floor and matched to floor thickness.
  - 2. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
  - 3. Closure Plug: Arranged to close unused 3 inch (75 mm) cored openings and reestablish fire rating of floor.
  - 4. Wiring: Three No. 12 AWG power and ground conductors; one 75 ohm coaxial telephone/data cable; and one four-pair, 75 ohm telephone/data cable.

## 2.9 MULTIOUTLET ASSEMBLIES

- A. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- B. Raceway Material: Metal, with manufacturer's standard finish.
- C. Wire: No. 12 AWG.

# 2.10 COMMUNICATIONS OUTLETS

- A. Telephone Outlet:
  - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper; 3560-6.
    - b. Leviton; 40649.
  - 3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1 complying with Category 5e. Comply with UL 1863.
- B. Combination TV and Telephone Outlet:
  - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper; 3562.
    - b. Leviton; 40595.
  - 3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

### 2.11 TELEPHONE/POWER SERVICE POLES

- A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
  - 1. Poles: Nominal 2.5-inch (65 mm) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.
  - 2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
  - 3. Finishes: One of manufacturers standard finish and trim combinations, including painted and satin anodized-aluminum finishes and wood-grain-type trim.
  - 4. Wiring: Sized for three No. 12 AWG power and ground conductors and telephone/data cable as indicated.
  - 5. Power Receptacles: Two single, 20-A; heavy-duty, NEMA WD 6, Configuration 5-20R units.
  - 6. Signal Outlets: Blank insert with bushed cable opening except as otherwise indicated.

## 2.12 WIRING DEVICE AND COVER FINISHES

- A. Color Plastic:
  - 1. Covers for Wiring Devices Connected to Normal Power System are to be selected based on final approved finishes into which the device is to be installed. Wiring devices are to match covers unless required by NFPA 70 or on emergency power system. Wiring devices connected to Emergency Power System are to be red.
  - 2. Covers on devices installed into CMU or drywall finishes shall generally be white, except for devices installed into wood, tile or stone wall finishes or casework. Devices installed into such materials shall be identified and coordinated with the finish and supplied with color chips for final selection by the interiors group.

PART 3 - EXECUTION

# 3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
  - 1. Install devices and assemblies level, plumb, and secure.
  - 2. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
  - 3. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  - 4. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  - 5. Install wiring devices after all wall preparation, including painting, is complete.

- C. Tamper Resistant Receptacles:
  - 1. Provide tamper resistant type receptacles where specifically indicated on drawings or in any building where children 7 and under may be present. Tamper resistant devices to be provided, but not limited to the following spaces, commercial building public spaces, elementary education, day care, government buildings public spaces.
- D. Conductors:
  - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
  - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
  - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
  - 4. Existing Conductors:
    - a. Cut back and pigtail, or replace all damaged conductors.
    - b. Straighten conductors that remain and remove corrosion and foreign matter.
    - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.
- E. Device Installation:
  - 1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
  - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
  - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
  - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches(152 mm) in length.
  - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
  - 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
  - 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
  - 8. Tighten unused terminal screws on the device.
  - 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
  - 10. Provide an individual GFCI receptacle for each one shown on the drawings. Do not feed downstream receptacles on the same circuit using the protection of a GFCI receptacle.
  - 11. Where GFCI receptacles are concealed behind either fixed or removable equipment, provide remote GFCI test device per NFPA-70 requirements.
- F. Receptacle Orientation:
  - 1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.
- G. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- H. Dimmers:

- 1. Install dimmers within terms of their listing.
- 2. Verify that dimmers used for fan speed control are listed for that application.
- 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- I. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical. Group adjacent switches under single, multigang wall plates.
- J. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

### 3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
  - 1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

## 3.3 CONNECTIONS

- A. Connect receptacles using screw-compression wiring contacts or pigtail leads. Do not use push-in contacts.
- B. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.
- C. Isolated-Ground Receptacles: Connect to isolated-ground conductor routed to designated isolated equipment ground terminal of electrical system.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- 3.4 FIELD QUALITY CONTROL
- A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.
- B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- C. Remove damaged and defective components.
- 3.5 CLEANING
- A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

#### END OF SECTION 26 2726
# SECTION 26 2813 - FUSES

## PART 1 - GENERAL

## 1.1 SUMMARY

- A. Section Includes:
  - 1. Cartridge fuses rated 600 V ac and less for use in the following:
    - a. Control circuits.
    - b. Motor-control centers.
    - c. Panelboards.
    - d. Switchboards.
    - e. Enclosed controllers.
    - f. Enclosed switches.

# 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- 1.3 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

### 1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA FU 1 for cartridge fuses.
- C. Comply with NFPA 70.

### 1.5 COORDINATION

A. Coordinate fuse rating with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

# 1.6 EXTRA MATERIALS

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

1. Spare Fuses: Furnish two sets of each fuse type and size installed.

## PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide fuses by one of the following:
  - 1. Cooper Bussmann, Inc.
  - 2. Ferraz Shawmut, Inc.
  - 3. Littelfuse, Inc.

## 2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
  - 1. Type RK-1: 250 600-V, zero- to 600-A rating, 200 kAIC, time delay.
  - 2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, time delay.
  - 3. Type CD: 600-V, 31- to 60-A rating, 200 kAIC , time delay.
  - 4. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
  - 5. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
  - 6. Type T: 250-V, zero- to 1200-A 600-V, zero- to 800-A rating, 200 kAIC, time delay.

# 2.3 SPARE FUSE CABINET

- A. Cabinet: Wall-mounted, 0.05 inch(1.27 mm) thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
  - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
  - 2. Finish: Gray, baked enamel.
  - 3. Identification: "SPARE FUSES" in 1-1/2-inch(40-mm) high letters on exterior of door.
  - 4. Fuse Pullers: For each size fuse.

#### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.2 FUSE APPLICATIONS

- A. Service Entrance: Class L, fast acting.
- B. Feeders: Class L or Class J, time delay.
- C. Motor Branch Circuits: Class RK1, time delay.
- D. Other Branch Circuits: Class RK5, time delay.
- E. Control Circuits: Class CC, time delay.

# 3.3 INSTALLATION

- A. Install fuses in fusible devices as indicated. Arrange fuses so fuse ratings are readable without removing fuse.
- B. Install spare fuse cabinet(s).

# 3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block and holder.

# END OF SECTION 26 2813

## **SECTION 26 3213 - ENGINE GENERATORS**

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes packaged natural gas engine generator sets with the following features and accessories:
  - 1. Battery charger.
  - 2. Engine generator set.
  - 3. Muffler.
  - 4. Exhaust piping external to set.
  - 5. Outdoor enclosure.
  - 6. Remote annunciator.
  - 7. Radiator.
  - 8. Remote stop switch.
  - 9. Starting battery.
- B. See Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

#### 1.2 DEFINITIONS

- A. Standby Rating: Power output rating equal to the power the generator set delivers continuously under normally varying load factors for the duration of a power outage.
- B. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
- C. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

# 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of packaged engine generator and accessory indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
- B. Field quality-control test reports.

- C. Warranty: Special warranty specified in this Section.
- 1.5 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

## 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with ASME B15.1.
- E. Comply with NFPA 37.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- I. Comply with UL 2200.
- J. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- K. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

### 1.7 PROJECT CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient Temperature: Minus 15 to plus 40 deg C.
  - 2. Relative Humidity: 0 to 95 percent.
  - 3. Altitude: Sea level to 1000 feet (300 m).

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver engine generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

## 1.9 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace packaged engine generator and auxiliary components that fail in materials or workmanship within specified warranty period. The warranty shall have not deductibles.
  - 1. Warranty Period: Five years from date of Substantial Completion.

## 1.10 MAINTENANCE SERVICE

A. Maintenance: At Substantial Completion, begin 12 months' full maintenance by skilled employees of the manufacturer's designated service organization. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts and supplies as used in the manufacture and installation of original equipment.

# 1.11 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Indicator Lamps: Two for every six of each type used, but not less than two of each.
  - 2. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

# PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Caterpillar, Inc.; Engine Div.
  - 2. Cummins Power Generation.
  - 3. Generac Corp.
  - 4. Kohler Co; Generator Division.
  - 5. MTU Detroit Diesel.

# 2.2 ENGINE GENERATOR SET

- A. Furnish a coordinated assembly of compatible components.
- B. Safety Standard: Comply with ASME B15.1.
- C. Nameplates: Each major system component is equipped with a conspicuous nameplate of component manufacturer. Nameplate identifies manufacturer of origin and address, and model and serial number of item.
- D. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
- E. Skid: Adequate strength and rigidity to maintain alignment of mounted components without depending on a concrete foundation. Skid is free from sharp edges and corners. Lifting attachments are arranged to facilitate lifting with slings without damaging any components.
- F. GENERATOR-SET PERFORMANCE
  - 1. Oversizing generator compared with the rated power output of the engine to meet performance requirements in paragraphs below is permissible.
  - 2. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
  - 3. Steady-State Voltage Operational Bandwidth: 2 percent of rated output voltage from no load to full load.
  - 4. Steady-State Voltage Modulation Frequency: Less than 1 Hz.
  - 5. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage recovers to remain within the steady-state operating band within 0.5 second.
  - 6. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
  - 7. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there are no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  - 8. Transient Frequency Performance: Less than 2-Hz variation for a 50 percent step-load increase or decrease. Frequency recovers to remain within the steady-state operating band within three seconds.
  - 9. Output Waveform: At no load, harmonic content measured line to neutral does not exceed 2 percent total with no slot ripple. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50.
  - 10. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, the system will supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or any other generator system component.
  - 11. Excitation System: Performance is unaffected by voltage distortion caused by nonlinear load.
  - G. Start Time: Comply with NFPA 110, Type 10, system requirements.

## 2.3 SERVICE CONDITIONS

- A. Environmental Conditions: Engine generator system withstands the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient Temperature: 122 degrees F. Suitable for application in Michigan.
  - 2. Altitude: Sea level to 1000 feet (300 m).

# 2.4 ENGINE

- A. Comply with NFPA 37.
- B. Fuel: Natural Gas.
- C. Rated Engine Speed: 1800 rpm.
- D. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- E. Lubrication System: Pressurized by a positive-displacement pump driven from engine crankshaft. The following items are mounted on engine or skid:
  - 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
  - 2. Thermostatic Control Valve: Controls flow in system to maintain optimum oil temperature. Unit is capable of full flow and is designed to be fail-safe.
- F. Engine Fuel System: Comply with NFPA 37. System includes the following:
  - 1. Secondary Gas Regulator.
  - 2. Fuel Shutoff Valve.
  - 3. Fuel Strainer and UL Listed Flexible Fuel Line.
- G. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Heater shall be thermostatically controlled. Comply with NFPA 110 requirements for Level 1 equipment.
- H. Vibration isolation between generator and concrete pad.
- 2.5 GOVERNOR: Adjustable isochronous, with speed sensing, electronic type.

# 2.6 ENGINE COOLING SYSTEM

- A. Description: Closed loop, liquid cooled, with radiator factory mounted on engine generator-set skid and integral engine-driven coolant pump.
- B. Radiator: Rated for specified coolant.
- C. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

- D. Expansion Tank: Constructed of welded steel plate and equipped with gage glass and petcock.
- E. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
- F. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
  - 1. Rating: 50-psig(345-kPa) maximum working pressure with 180 deg F(82 deg C) coolant, and noncollapsible under vacuum.
  - 2. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- G. Coolant piping external to engine generator set. Refer to Division 23 Section "Hydronic Piping" for materials and installation requirements for piping.

## 2.7 FUEL SUPPLY SYSTEM

- A. Comply with NFPA 37.
- B. Interior Natural Gas Piping: As specified in Division 23 Section "Facility Natural Gas Piping."

#### 2.8 ENGINE EXHAUST SYSTEM

- A. Muffler: Critical type, sized as recommended by engine manufacturer. Muffler shall reduce exhaust noise 30 dBA or better at 500Hz.
- B. Condensate Drain for Muffler: Schedule 40, black steel pipe connected to muffler drain outlet through a petcock.
- C. Connections from Engine to Exhaust System: Flexible section of corrugated stainless-steel pipe.
- D. Connection from Exhaust Pipe to Muffler: Stainless-steel expansion joint with liners.
- E. Insulation for Mufflers and Indoor Exhaust Piping: As specified in Division 23 Section "HVAC Equipment Insulation" and Division 23 Section "HVAC Piping Insulation."
- F. Supports for Muffler and Exhaust Piping: Spring hangers and all-thread rods and vibration hangers as specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" and Division 23 Section "Hangers and Supports for HVAC Piping and Equipment"; attached to building structure.
- G. Exhaust Piping External to Engine: ASTM A 53, Schedule 40, welded, black steel, with welded joints and fittings. Refer to Division 23 Section "Engine Exhaust Systems."
- H. Rain Cap.

## 2.9 COMBUSTION-AIR-INTAKE

A. Description: Standard-duty engine-mounted air cleaner with replaceable dry filter element and "blocked filter" indicator.

## 2.10 STARTING SYSTEM

- A. Description: 24-V electric, with negative ground and including the following items:
  - 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above.
  - 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
  - 3. Cranking Cycle: As required by NFPA 110 for system level specified.
  - 4. Battery: Adequate capacity within ambient temperature range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above to provide specified cranking cycle at least twice without recharging.
  - 5. Battery Cable: Size as recommended by generator set manufacturer for cable length required. Include required interconnecting conductors and connection accessories.
  - 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater is arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above. Include accessories required to support and fasten batteries in place.
  - 7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
  - 8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type with equalize charge timer. Unit complies with UL 1236 and includes the following features:
    - a. Operation: Equalizing-charging rate of 10 A is initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit then automatically switches to a lower float-charging mode and continues operating in that mode until battery is discharged again.
    - b. Automatic Temperature Compensation: Adjusts float and equalizes voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    - c. Automatic Voltage Regulation: Maintains output voltage constant regardless of input voltage variations up to plus or minus 10 percent.
    - d. Ammeter and Voltmeter: Flush mounted in door. Meters indicate charging rates.
    - e. Safety Functions: Include sensing of abnormally low battery voltage arranged to close contacts providing low battery voltage indication on control and monitoring panel. Also include sensing of high battery voltage and loss of ac input or dc output of battery charger. Either condition closes contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.
  - 9. Battery Heater: Provide battery heater for each battery in outdoor installations.

## 2.11 CONTROL AND MONITORING

- A. Functional Description: When the mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic-transfer switches initiate starting and stopping of the generator set. When the mode-selector switch is switched to the on position, the generator set manually starts. The off position of the same switch initiates generator-set shutdown. When the generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.
- B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages are grouped on a common control and monitoring panel mounted on the generator set. Mounting method isolates the control panel from generator-set vibration.
  - 1. Current and Potential Transformers: Instrument accuracy class.
- C. Indicating and Protective Devices and Controls: Include those required by NFPA 110 for a Level 1 system, and the following:
- D. Indicating and Protective Devices and Controls: Include the following:
  - 1. AC voltmeter.
  - 2. AC ammeter.
  - 3. AC frequency meter.
  - 4. DC voltmeter (alternator battery charging).
  - 5. Engine-coolant temperature gage.
  - 6. Engine lubricating-oil pressure gage.
  - 7. Running-time meter.
  - 8. Ammeter-voltmeter, phase-selector switch(es).
  - 9. Generator-voltage adjusting rheostat.
  - 10. Generator overload.
- E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices, and wiring required to support specified items. Locate sensors and other supporting items on engine, generator, or elsewhere as indicated. Where not indicated, locate to suit manufacturer's standard.
- F. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data link transmission of indications to remote data terminals. Data link module shall have all related components of the generator set, remote annunciator and be compatible with the automatic transfer switch.
- G. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel. Locate audible device and silencing means where indicated.
- H. Remote Alarm Annunciator: Communications ready and installed by twisted pair wiring. Comply with NFPA 99. Labeled LEDs identify each alarm event. Common audible signal sounds for alarm conditions. Silencing switch in face of panel silences signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

I. Remote Emergency-Stop Switch: Flush wall-mounted, unless otherwise indicated and prominently labeled. Push button is protected from accidental operation.

## 2.12 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.
  - 1. Tripping Characteristic: Designed specifically for generator protection.
  - 2. Trip Rating: Matched to generator rating.
  - 3. Shunt Trip: For future use.
  - 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Ground-Fault Indication: Comply with NFPA 70, Article 700-7(d). Integrate ground-fault alarm indication with other generator-set alarm indications.

## 2.13 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1 and specified performance requirements.
- B. Drive: Generator shaft is directly connected to engine shaft. Exciter is rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction prevents mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Excitation uses no slip or collector rings, or brushes, and is arranged to sustain generator output under short-circuit conditions as specified.
- G. Enclosure: Dripproof.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
  - 1. Adjusting rheostat on control and monitoring panel provides plus or minus 5 percent adjustment of output- voltage operating band.
- I. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- J. Alternator: 125C rise rated.
- K. Alternator Heater.

# 2.14 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels are lockable and provide adequate access to components requiring maintenance. Panels are removable by one person without tools. Instruments and control are mounted within enclosure. Provide skid bottom end plates.
- B. Description: Prefabricated or pre-engineered enclosure with the following features:
  - 1. Construction: Galvanized steel, metal-clad on steel frame.
  - 2. Sound Attenuating Enclosure: Provide (Level 1) (Level 2) sound attenuation rating.
  - 3. Structural Design and Anchorage: Adequate to resist loads imposed by 100-mph (160-km/h) wind.
  - 4. Space Heater: Thermostatically controlled operating at one-half or less of rated voltage sized to prevent condensation.
  - 5. Louvers: Equipped with insect/rodent screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust and rodents.
  - 6. Hinged Doors: Doors shall have lift off door hinges with padlocking provisions. All doors will be key lockable with all locks keyed alike. A key will be supplied for each door lock.
  - 7. Hardware: Enclosures shall have stainless steel hardware including door latch striker plates.
  - 8. Ventilation: Louvers equipped with insect/rodent screen and filter arranged to permit air circulation while excluding exterior dust and rodents.
  - 9. Thermal Insulation: As required to maintain winter interior temperature within limits required by components.
  - 10. Finish: Two-coat enamel finish over cleaned and primed surfaces.
- C. Muffler Location: Internal to enclosure.
- D. Engine Cooling Airflow through Enclosure: Adequate to maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
- E. Louvers: Fixed-engine cooling air inlet and discharge. Louvers prevent entry of rain and snow.
- F. Interior Lights: With switch. Factory-wired, LED vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external circuit supply.
- G. Convenience Outlets: Factory wired. Arrange for external circuit supply.

#### 2.15 FINISHES

- A. Indoor Enclosures and Components: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.
- B. Outdoor Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.

# 2.16 SOURCE QUALITY CONTROL

- A. Factory Tests: Include prototype testing and Project-specific equipment testing (testing of equipment manufactured specifically for this Project).
- B. Prototype Testing: Performed on a separate engine generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
  - 1. Tests: Comply with those required for Level 1 energy converters in Paragraphs 3.2.1, 3.2.1.1, and 3.2.1.2 of NFPA 110.
  - 2. Generator Tests: Comply with IEEE 115.
  - 3. Components and Accessories: Items furnished with installed unit that are not identical to those on tested prototype have been tested to demonstrate compatibility and reliability.
- C. Project-Specific Equipment Tests: Factory test engine generator set and other system components and accessories before shipment. Perform tests at rated load and power factor. Include the following tests.
  - 1. Full load run.
  - 2. Maximum power.
  - 3. Voltage regulation.
  - 4. Transient and steady-state governing.
  - 5. Single-step load pickup.
  - 6. Safety shutdown.
- D. Observation of Factory Tests: Provide 14 days' advance notice of tests and opportunity for observation of test by Owner's representatives.
- E. Report factory test results within 10 days of completion of test.

# PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Examine roughing-in of cooling-system piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

# 3.2 CONCRETE BASES

A. Install concrete bases of dimensions recommended by manufacturer for packaged engine generators. Refer to Division 03 "Cast-in-Place Concrete."

## 3.3 INSTALLATION

- A. Packaged Engine Generator sets shall be installed in accordance with NECA/EGSA 404-2000, Recommended Practice for Installing Generator Sets (ANSI).
- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions, and with NFPA 110.
- C. Set packaged engine generator set on concrete bases.
  - 1. Support generator-set mounting feet on rectangular metal blocks and shims or on metal wedges having small taper, at points near foundation bolts to provide 3/4- to 1-1/2-inch (19- to 38-mm) gap between pump base and foundation for grouting.
  - 2. Adjust metal supports or wedges until generator is level.
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
  - 1. Verify that electrical wiring is installed according to manufacturers' submittal and installation requirements in Division 26 Sections. Proceed with equipment startup only after wiring installation is satisfactory.

# 3.4 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
  - 1. Install piping adjacent to packaged engine generator to allow service and maintenance.
  - 2. Connect water supply to cooling system.
  - 3. Connect cooling-system water supply and drain piping to engine heat exchangers. Install flexible connectors at connections to engine generator and remote radiator.
  - 4. Connect exhaust-system piping to engines.
- B. Electrical wiring and connections are specified in Division 26 Sections.
- C. Ground equipment.
  - 1. Provide at least 3-ground rods at the generator location.
  - Tighten electrical connectors and terminals according to manufacturer's published torquetightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.5 IDENTIFICATION

A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems".

## 3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect fieldassembled components and equipment installation, including piping and electrical connections, and to assist in testing. Report results in writing.
- B. Testing: Perform field quality-control testing under the supervision of the manufacturer's factoryauthorized service representative.
- C. Tests: Include the following:
  - 1. Tests recommended by manufacturer.
  - 2. Perform each visual and mechanical inspection and electrical and mechanical test stated in manufacturer's recommendations for emergency engine generator sets.
  - 3. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 1996 Edition. The authority having jurisdiction (Office of Fire Safety, Michigan Department of Consumer and Industry Services), shall be given advanced notification of the time at which the final test is to be performed so that the authority can witness the test. Provide signed documentation to the authority having jurisdiction documenting that these requirements have been met. Loadbank test to full capacity for 4 hours in addition to building load test.
  - 4. Battery Tests: Measure charging voltage and voltages between available battery terminals for fullcharging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
  - 5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  - 6. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  - 7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  - 8. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
- D. Coordinate tests with tests for transfer switches and run them concurrently.
- E. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- G. Test instruments shall have been calibrated within the last 12 months, traceable to standards of the National Institute for Standards and Technology, and adequate for making positive observation of test results. Make calibration records available for examination on request.

## 3.7 BATTERY EQUALIZATION

- A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
- 3.8 CLEANING
  - A. On completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

## 3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators as specified below:
  - 1. Coordinate this training with that for transfer switches.
  - 2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
  - 3. Review data in maintenance manuals. Refer to Division 01 Section "Contract Closeout."
  - 4. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."
  - 5. Schedule training with Owner, through Architect, with at least seven days' advance notice.
  - 6. Minimum Instruction Period: Eight hours.

# END OF SECTION 26 3213

## **SECTION 26 3600 - TRANSFER SWITCHES**

PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
  - 1. Automatic transfer switches.
  - 2. Bypass/isolation switches.
  - 3. Nonautomatic transfer switches.
  - 4. Remote annunciation systems.
  - 5. Remote annunciation and control systems.
- B. Related Sections include the following:
  - 1. Division 21 Section "Electric-Drive, Centrifugal Fire Pumps" for automatic transfer switches for fire pumps.
  - 2. Division 21 Section "Electric-Drive, Vertical-Turbine Fire Pumps" for automatic transfer switches for fire pumps.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
  - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

# 1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

## 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
  - 1. Features and operating sequences, both automatic and manual.
  - 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

## 1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
  - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise onsite testing specified in Part 3.
- C. Source Limitations: Obtain automatic transfer switches, remote annunciator and control panels through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.

# 1.7 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:
  - 1. Notify Construction Manager Owner no fewer than ten days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Construction Manager's Owner's written permission.

## 1.8 COORDINATION

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

## 1.9 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights. Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace transfer switch and auxiliary components that fail in materials of workmanship within specified warranty period. The warranty shall have no deductibles.
  - 1. Warranty Period: Five years from date of Substantial Completion.
  - 2. Warranty to include: parts, labor and travel time for five years.

# PART 2 - PRODUCTS

# 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Conventional Transfer Switches:
    - a. Caterpillar; Engine Div.
    - b. Emerson; ASCO Power Technologies, LP.
    - c. Generac Power Systems, Inc.
    - d. GE Zenith Controls.
    - e. Kohler Power Systems; Generator Division.
    - f. Cummins Power Generation; Industrial Business Group.
    - g. Russelectric, Inc.
    - h. Spectrum Detroit Diesel.

# 2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

- 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
- 2. When fault-current value is not indicated on transfer switch, meet or exceed the KA fault current rating of upstream panel with "any breaker" fully rated available fault current rating.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motoroperated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
  - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuitbreaker components are not acceptable.
  - 2. Switch Action: Double throw; mechanically held in both directions.
  - 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by colorcode or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
  - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
  - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
  - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- J. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

# 2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

- C. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- D. Signal-before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- E. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:
  - 1. Fully automatic make-before-break operation.
  - 2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
  - 3. Initiation of No-Interruption Transfer: Controlled by phase angle monitor and sensors confirming both sources are present and acceptable.
    - a. Initiation occurs without active control of generator set.
    - b. Controls ensure closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees, maximum and plus or minus 5 percent maximum voltage difference.
  - 4. Failure of the power source serving the load initiates automatic break-before-make transfer.
- F. Automatic Transfer-Switch Features:
  - 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
  - 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
  - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
  - 4. Provide with Phase angle monitoring between phases, phase rotation sensing and digital fault history display.
  - 5. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
  - 6. Test Switch: Simulate normal-source failure.
  - 7. Switch-Position Pilot Lights: Indicate source to which load is connected.
  - 8. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergencysource sensing circuits.
    - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
  - 9. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

- 10. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
- 11. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
- 12. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote enginegenerator controls after retransfer of load to normal source.
- 13. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
- 14. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
  - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
  - b. Push-button programming control with digital display of settings.
  - c. Integral battery operation of time switch when normal control power is not available.

# 2.4 BYPASS/ISOLATION SWITCHES

- A. Comply with requirements for Level 1 equipment per NFPA 110.
- B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
  - 1. Means to lock bypass/isolation in the position that isolates transfer switch, with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
  - 2. Drawout Arrangement for Transfer Switch: Provides physical separation from live parts and accessibility for testing and maintenance operations.
  - 3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with the same phase arrangement and number of poles.
  - 4. Contact temperatures of bypass/isolation switches do not exceed those of automatic transferswitch contacts when they are carrying rated load.
  - 5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less.
  - 6. Legend: Manufacturer's standard legend for control labels and instruction signs give detailed operating instructions.
  - 7. Maintainability: Fabricate to allow convenient removal of major components from the front without removing other parts or main power conductors.
- C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars, plated at connection points and braced for the indicated available short-circuit current.

#### 2.5 NONAUTOMATIC TRANSFER SWITCHES

- A. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- B. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." In addition, removable manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.
- C. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.
- D. Nonautomatic Transfer-Switch Accessories:
  - 1. Pilot Lights: Indicate source to which load is connected.
  - 2. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternatesource sensing circuits.
    - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    - b. Emergency Power Supervision: Red light with nameplate engraved "Alternate Source Available."
  - 3. Unassigned Auxiliary Contacts: One set of normally closed contacts for each switch position, rated 10 A at 240-V ac.

#### 2.6 FINISHES

A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

## 2.7 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

# PART 3 - EXECUTION

- 3.1 APPLICATION
  - A. Four-Pole Switches: Where four-pole switches are indicated, install neutral switching.
- 3.2 INSTALLATION
  - A. Floor-Mounted Switch: Level and anchor unit to floor.

- B. Floor-Mounting Switch: Anchor to floor by bolting.
  - 1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 26 Section "Identification for Electrical Systems."
- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

## 3.3 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Generator Run Status to Elevator
  - 1. Provide conduit and wire between the transfer switch and each elevator controller.
  - 2. Notify each elevator controller when the building is operating on emergency power
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

# 3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
  - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

- a. Check for electrical continuity of circuits and for short circuits.
- b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
- c. Verify that manual transfer warnings are properly placed.
- d. Perform manual transfer operation.
- 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
  - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
  - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
  - c. Verify time-delay settings.
  - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
  - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
  - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
  - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- 6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
  - a. Verify grounding connections and locations and ratings of sensors.
- D. Testing Agency's Tests and Inspections:
  - 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    - a. Check for electrical continuity of circuits and for short circuits.
    - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    - c. Verify that manual transfer warnings are properly placed.
    - d. Perform manual transfer operation.
  - 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    - c. Verify time-delay settings.
    - d. Verify pickup and dropout voltages by data readout or inspection of control settings.

- e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
- f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
- g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- 5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
  - a. Verify grounding connections and locations and ratings of sensors.
- E. Coordinate tests with tests of generator and run them concurrently.
- F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- G. Remove and replace malfunctioning units and retest as specified above.
- H. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
  - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
  - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

# 3.5 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean equipment internally, on completion of installation, according to manufacturer's written instructions.

# 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain transfer switches and related equipment as specified below:
  - 1. Coordinate this training with that for generator equipment.
  - 2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
  - 3. Review data in maintenance manuals. Refer to Division 01 Section "Closeout Procedures."
  - 4. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."

- Schedule training with Owner, through Architect, with at least seven days' advance notice. Provide a minimum of four hours of instruction. 5.
- 6.

# END OF SECTION 26 3600

## SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Requirements:
  - 1. Section 26 2413 "Switchboards" for factory-installed SPDs.
  - 2. Section 26 2416 "Panelboards" for factory-installed SPDs.

## 1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

## PROJECT NO. 18-168.00 SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 4313 - 2 HRA 10/24/2019 PERMIT SET

- Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
- 1.5 INFORMATIONAL SUBMITTALS
  - A. Field quality-control reports.
  - B. Sample Warranty: For manufacturer's special warranty.

# 1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

# 1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five years from date of Substantial Completion.

# PART 2 - PRODUCTS

# 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advanced Protection Technologies Inc. (APT).
  - 2. Current Technology, Inc.
  - 3. Eaton Corporation.
  - 4. Emerson Electric Co. (Liebert)
  - 5. GE Zenith Controls.
  - 6. LEA International; Protection Technology Group.
  - 7. Leviton Manufacturing Co., Inc.
  - 8. PowerLogics, Inc.
  - 9. Schneider Electric Industries SAS.
  - 10. Siemens Industry, Inc.

# 2.2 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.

## PROJECT NO. 18-168.00 SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 4313 - 3 HRA 10/24/2019 PERMIT SET

- C. Comply with UL 1449.
- D. MCOV of the SPD shall be at least 125 percent of the nominal system voltage.

## 2.3 SERVICE ENTRANCE AND TRANSFER SWITCH SUPPRESSOR

- A. SPDs: Comply with UL 1449, Type 2.
- B. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2
  - 1. SPDs with the following features and accessories:
    - a. Integral disconnect switch.
    - b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
    - c. Indicator light display for protection status.
    - d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
    - e. Surge counter.
- C. Comply with UL 1283.
- D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
  - 2. Line to Ground: 1200 V for 480Y/277 V 1200 V for 208Y/120 V.
  - 3. Line to Line: 2000 V for 480Y/277 V 1000 V for 208Y/120 V.
- F. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 700 V.
  - 2. Line to Ground: 1000 V.
  - 3. Line to Line: 1000 V.
- G. SCCR: Equal or exceed 200 kA.
- H. Inominal Rating: 20 kA.
- 2.4 PANEL SUPPRESSORS
  - A. SPDs: Comply with UL 1449, Type 2.

## PROJECT NO. 18-168.00 SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 4313 - 4 HRA 10/24/2019 PERMIT SET

1. Include LED indicator lights for power and protection status.

- 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
- 3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
- B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- C. Comply with UL 1283.
- D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
  - 2. Line to Ground: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
  - 3. Neutral to Ground: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
  - 4. Line to Line: 2000 V for 480Y/277 V 1200 V for 208Y/120 V
- E. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 700 V.
  - 2. Line to Ground: 700 V.
  - 3. Neutral to Ground: 700 V.
  - 4. Line to Line: 1200 V.
- F. SCCR: Equal or exceed 200 kA.
- G. Inominal Rating: 20 kA.

# 2.5 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

# 2.6 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

## PROJECT NO. 18-168.00 SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 4313 - 5 HRA 10/24/2019 PERMIT SET

PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Comply with NECA 1.
- B. SPD units shall be factory mounted in respective branch circuit panelboard, distribution panel, motor control center or switchboard enclosure.
- C. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.
- D. Where SPD unit is shown to be installed as an out-board unit (such as existing panelboard) install conductors between suppressor and points of attachment as short and straight as possible. Desired lead length for phase and neutral conductors is 16 inches or less. In no case, shall the leads exceed 30 inches. Do not bond neutral and ground.
  - 1. Provide multipole, circuit breaker (size in accordance with manufacturer's recommendations) as a dedicated disconnect for the suppressor, unless otherwise indicated.
- E. After testing, disable or disconnect SPD unit until time of substantial completion. This is to eliminate deterioration of the unit during construction period.
- F. Wiring:
  - 1. Power Wiring: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
  - 2. Controls: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

#### 3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
  - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
  - 2. Inspect anchorage, alignment, grounding, and clearances.
  - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

## 3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

# PROJECT NO. 18-168.00 SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 26 4313 - 6 HRA 10/24/2019 PERMIT SET

- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

## 3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

## END OF SECTION 26 4313

# **SECTION 26 5100 - INTERIOR LIGHTING**

PART 1 - GENERAL

## 1.1 SUMMARY

- A. Section Includes:
  - 1. Interior lighting fixtures, LED modules and drivers.
  - 2. Emergency lighting units.
  - 3. Exit signs.
  - 4. Lighting fixture supports.
  - 5. Retrofit kits for LED lighting fixtures.
- B. Related Sections:
  - 1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
  - 2. Division 26 Section "Network Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
  - 3. Division 26 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

# 1.2 ACTION SUBMITTALS

- A. General: Some lighting fixtures may require at least 3 to 4 months of lead time. The Contractor is responsible for allowing sufficient time for the review process, manufacturing and delivery of these products. Substitutions will not be accepted on the basis of the Contractor's obligation to meet project completion deadlines.
- B. Lighting Fixtures Specified: The lighting fixtures specified in these documents have been carefully chosen for their ability to meet lighting requirements for this project. Selection has been based on esthetics, durability, ease of maintenance, luminance ratios, vertical and horizontal illuminances, lumen maintenance, CRI, efficacy, LED system life and warranty as well as their ability to satisfy governing codes such as ASHRAE/IES 90.1/1999. The Contractor is cautioned that substitute products are likely to be unable to meet all of the same criteria as the product specified.
- C. Substitutions: When proposing substitute products, the Contractor shall be responsible for the negotiation with the Owner and Architect/Engineer, prior to substitution submittal, to assure fees are available to redesign the project based on the proposed substitutions or review by the Architect/Engineer of all photometric, sample, design and calculations for the proposed substitutions. All substitutions must be identified at time of bid. The Contractor's bid value shall not be based on substitutions in expectation of design team approval, nor on the Contractor's estimated value of the products specified. If review of the proposed substitute light fixtures finds the product unacceptable, the Contractor shall provide the fixtures specified at no additional cost to the Owner or delay in the project completion time.
- D. Product Data: For each type of lighting fixture and lamp indicated, arranged in order of fixture designation. Submit fixture data in bound brochure. Include illustrations and dimensions of fixtures, and showing photometric performance. Include data on features, accessories, and the following:

- 1. Contract Drawing light fixture type designation.
- 2. Dimensions of fixtures.
- 3. Certified results of independent laboratory tests of fixtures and lamps for electrical ratings and photometric data.
- 4. Emergency lighting unit battery and charger.
- 5. LED fixture LM79, LM80 and TM21 testing data.
- 6. Written Warranty Compliance
- E. Lighting Fixture Submittals: Fixture cuts lacking sufficient detail to indicate compliance with specifications will not be acceptable.
- F. Shop Drawings: Show details of nonstandard and custom fixtures. Indicate dimensions, weights, components, features, accessories, and methods of field assembly and mounting.
  - 1. Wiring Diagrams: Detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.
- G. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 01.

## 1.3 QUALITY ASSURANCE

- A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NFPA 70.
- C. Comply with LM 79, LM80 and TM21 LED testing standards.
- D. FM Compliance: Fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM.
- E. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.
- F. Office of Fire Safety: All plastic diffusers used in lighting fixtures or luminous ceilings shall conform with NFPA 101, Life Safety Code, 1997 Edition, Section 6-5, Interior Finish. The light fixture manufacturer(s) shall furnish an affidavit stating compliance with this requirement for submittal to the State of Michigan Department of Labor & Economic Growth, Office of Fire Safety, P.O. Box 30254, Lansing, Michigan 48909.

#### 1.4 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.
#### 1.5 WARRANTY

- A. Special Warranty for Batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period.
  - 1. Special Warranty Period for Batteries: Manufacturer's standard, but not less than 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for last nine years.
- B. Warranty for LED fixtures: Written warranty, agreeing to replace drivers, LED modules and any fixture housing or components that fail in materials and workmanship within minimum (5) years from date of purchase. Warranty shall provide materials necessary to restore to acceptable operation. Labor shall be warrantied for two years of the project substantial completion. The warranty shall include fixture replacement or component replacement if the luminaire delivers less than 90% of the initial light level over the rated life.
  - 1. For decorative pendant and track fixtures, warranty shall be minimum of (5) years.
  - 2. All other fixtures shall match the standard warranty of the fixture specified.

#### PART 2 - PRODUCTS

#### 2.1 LIGHTING FIXTURE MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the plans.

# 2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- D. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
  - 1. White Surfaces: 85 percent.
  - 2. Specular Surfaces: 83 percent.
  - 3. Diffusing Specular Surfaces: 75 percent.
  - 4. Laminated Silver Metallized Film: 90 percent.
- E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.

- 1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
- 2. Lens Thickness: 0.125 inch (3 mm) minimum, unless greater thickness is indicated.
- F. Disconnecting Means: Provide disconnecting means for all LED fixtures. Disconnect shall comply with NEC Section 410.73(G).

# 2.3 LED FIXTURES

- A. GENERAL
  - 1. LED light fixtures shall meet all of the specified parameters with published independent testing in accordance with LM79, LM80 and TM21 testing standards.
  - 2. LED light fixtures shall be sold as a complete system. Light fixtures shall have minimum efficacy as follows:
    - a. Linear Recessed LED (2x2,2x4,1x4,1x2): 95 Lumens per watt.
    - b. Linear Recessed LED (~4", Narrow Aperture): 74 Lumens per watt.
    - c. Linear Pendant LED (~4" Aperture): 95 Lumens per watt up, 74 Lumens per watt down.
    - d. Downlight LED: 80 Lumens per watt.
  - 3. LED light fixtures shall have delivered lumen output within 5% of the delivered lumen output of the fixtures specified.
  - 4. LED light fixtures shall be dimmable down to 20% or less of full output. If the specified fixture is dimmable to a level lower than 20%, equivalent fixture must be dimmable to the same level or lower than the fixture specified.
  - 5. LED light fixture shall produce no noticeable variation in color temperature from one fixture to another by the same manufacturer. Color temperature shall be within 3-step MacAdam Ellipse.
- B. LED DRIVERS
  - 1. High performance LED driver to be 120/277V and wired for dimming or non-dimming. Provide with manufacturer tested compatible battery backup where indicated.
  - 2. Driver expected lifetime shall be over 100,000 hours.
  - 3. Total Harmonic Distortion Rating: Less than 20 percent.
  - 4. Minimum power factor shall be 94%.
- C. LED ENGINES
  - 1. Manufacturers: Refer to light fixture schedule, light fixture is ordered as a complete system including LED driver, light engine and housing from the LED light fixture manufacturer.
  - 2. LED Color Temperature and Minimum Color-Rendering Index:
    - a. Downlights: 4100 K and over 85 CRI
    - b. Linear LED: 4100 K and over 80 CRI
  - 3. LED Life:
    - a. Downlights: Rated average shall be 50,000 hours rated per LM79, LM80 and TM-21 standards.
    - b. Linear LED: Rated average shall be 100,000 hours rated per LM79, LM80 and TM-21 standards.
    - c. Track and pendant heads: Rated average shall be 50,000 hours to 70% rated per LM79, LM80 and TM-21 standards.

#### 2.4 EXIT SIGNS

- Α. General Requirements: Comply with UL 924 and the following:
  - 1. Refer to Lighting Fixture Schedule on the plans.
- Internally Lighted Signs: Features as follows: Β.
  - Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life. 1.
- C. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
  - Battery: Sealed, maintenance-free, nickel-cadmium type. 1.
  - Charger: Fully automatic, solid-state type with sealed transfer relay. 2.
  - 3. Operation: Relay automatically energizes lamp from unit when circuit voltage drops to 80 percent of nominal or below. When normal voltage is restored, relay disconnects lamps, and battery is automatically recharged and floated on charger.
- Wire Guard: Provide heavy chrome plated wire guards to protect fixtures installed in gymnasiums and D. multi-purpose rooms. 1.

#### 2.5 FINISHES

- Α. Fixtures: Manufacturer's standard, unless otherwise indicated.
  - 1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
  - 2. Metallic Finish: Corrosion resistant.

#### 2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angleiron supports and nonmetallic channel and angle supports.
- Β. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm). D.
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).
- F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Interior Lighting Systems shall be installed in accordance with NECA/IESNA 500, Recommended Practice for Installing Indoor Commercial Lighting Systems and NECA/IESNA 502-1999, Recommended Practice for Installing Industrial Lighting Systems.
- B. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials.
- C. Support for Fixtures in or on Grid-Type Suspended Ceilings: Support fixture using grid plus the following:
  - 1. Fixtures shall be positively attached to the ceiling grid system.
  - 2. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches(150 mm) from fixture corners.
  - 3. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner.
  - 4. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently of panel, with at least two 3/4-inch(20-mm) metal channels spanning and secured to ceiling tees.
- D. Suspended Fixture:
  - 1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
  - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with two separate stem hangers.
  - 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing, stem, or rod for suspension for each unit length of fixture chassis, including one at each end.
  - 4. Continuous Rows: Suspend from cable installed according to fixture manufacturer's written instructions and details on Drawings.
  - 5. Fixtures to be aligned and level, insure lenses are fastened properly in place.
  - 6. Any supports used to suspend fixture in exposed ceiling areas shall be installed as high as possible out of view and painted with ceiling.
  - 7. Mount remote type drivers out of site above ceilings or in painted enclosure.
- E. In Mechanical and Boiler Rooms, coordinate lighting fixture installation with mechanical piping, duct work, etc. Provide all required supporting rods and channel to bridge duct work and piping. Generally, mount fixtures 8-9 feet above floor unless noted otherwise. Avoid positioning above mechanical piping and ducts.

# 3.2 CONNECTIONS

- A. Ground equipment.
  - 1. Tighten electrical connections and terminals according to manufacturer's published torquetightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.3 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

#### 3.4 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Provide instruments to make and record test results.
- C. Tests:
  - 1. Verify normal operation of each fixture after installation.
  - 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
  - 3. Verify normal transfer to battery source and retransfer to normal.
- D. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units are acceptable.
- E. Corroded Fixtures: Replace during warranty period.

#### 3.5 STARTUP SERVICE

A. Burn-in all fixtures that require specific aging period to operate properly, prior to occupancy by Owner.

#### 3.6 CLEANING AND ADJUSTING

- A. Clean fixtures internally and externally after installation. Fixture cones, reflectors, baffles, and visible trim shall be turned over to the owner clean and free of dust, drywall mud, smudges, fingerprints, and scratches. Only use methods and cleaning materials in accordance with respective fixture manufacturer recommendations.
- B. All adjustable light fixtures shall be aimed, focused and locked by the Contractor under the observation of the Architect/Engineer. When daylighting interferes with the aiming and focusing, aiming shall be accomplished during hours of darkness.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
  - 1. Adjust aimable luminaires in the presence of Architect.

# END OF SECTION 26 5100

# SECTION 26 5600 - EXTERIOR LIGHTING

PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Exterior luminaires with LED modules and drivers.
  - 2. Luminaire-mounted photoelectric relays.
  - 3. Poles and accessories.

# 1.2 ACTION SUBMITTALS

- A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
  - 1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
  - 2. Details of attaching luminaires and accessories.
  - 3. Details of installation and construction.
  - 4. Luminaire materials.
  - 5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
    - a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
  - 6. Photoelectric relays.
  - 7. LED fixture compliance of lumen maintenance, CRI, efficacy and LED system rated life and warranty.
  - 8. LED fixture LM79, LM80 and TM21 testing data.
  - 9. Materials, dimensions, and finishes of poles.
  - 10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
  - 11. Anchor bolts for poles.
  - 12. Manufactured pole foundations.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
  - 3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
  - 4. Wiring Diagrams: For power, signal, and control wiring.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- B. Field quality-control reports.
- C. Warranty: Sample of special warranty.
- D. LED fixture written warranty compliance.

#### 1.4 CLOSEOUT SUBMITTALS

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

# 1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 10 of each type and rating installed. Furnish at least one of each type.
  - 2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

#### 1.6 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with IEEE C2, "National Electrical Safety Code."
- D. Comply with NFPA 70.
- E. LED fixtures to be tested in compliance with LM79, LM80 and TM21 testing standards.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

- C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.
- D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
- E. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

# 1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
  - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
  - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
  - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
  - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.
  - 5. Warranty Period for LED fixtures: Minimum (5) years from date of Substantial Completion.
    - a. LED fixture warranty shall state agreement to replace LED drivers, LED light engine modules, fixture housing, components or accessories under the warranty coverage term.
    - b. Warranty shall include replacement of fixtures or components if the luminaire delivers less than 90% of the initial light level over the 100,000 hour life.
    - c. Fixture warranty to be extended to meet all requirements at a minimum of the warranty of the basis of design fixture specified.

# PART 2 - PRODUCTS

# 2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the plans.

# 2.2 LUMINAIRES

- A. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- B. Metal Parts: Free from burrs, sharp corners, and edges.
- C. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

- D. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit servicing without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during servicing and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange to disconnect driver when door opens.
- F. Exposed Hardware Material: Stainless steel.
- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
- H. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
  - 1. White Surfaces: 85 percent.
  - 2. Specular Surfaces: 83 percent.
  - 3. Diffusing Specular Surfaces: 75 percent.
- I. Fixture to be provided with all required accessories including (but not limited to) Luminaire, Arm or Mount, Pole, specified accessories.
- J. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor in luminaire doors.
- K. Photoelectric Relays: As follows:
  - 1. Contact Relays: Single throw, arranged to fail in the on position and factory set to turn light unit on at 1.5 to 3 fc(16 to 32 lx) and off at 4.5 to 10 fc(48 to 108 lx) with 15-second minimum time delay.
  - 2. Relay Mounting: In luminaire housing.

# 2.3 LED LIGHT FIXTURES:

- A. Light fixtures shall be UL listed and meet all of the specified parameters with published independent testing in accordance with LM79, LM80 and TM21 testing standards.
- B. Light fixtures shall be sold as a complete system. Light fixtures shall have a minimum efficacy of 75 lumens per watt or equal to that of the light fixture specified.
- C. Light fixtures shall have rated delivered lumen output within 5% of the rated delivered lumen output of the fixture specified.
- D. Light fixtures shall have accessible and replaceable drivers and LED light engine boards.
- E. LED drivers shall be 120/277V or 480V to match specified.LED drivers and light engines shall be Class 1 and have 100,000 hour rated life.
- F. Exterior fixtures to have one dimming driver per fixture head where dimming drivers are specified.
- G. LED driver Total Harmonic distortion shall be less than 20%.

- H. Light fixture minimum power factor shall be 90%.
- I. Light fixture color temperature shall be 4000K and minimum 90 CRI.
- J. Transient voltage surge suppression shall be 10kV integral to the fixture in accordance with IEEE/ANSI C62.41.2.
- K. Fixture shall be dark sky friendly.
- L. Fuses: One in each ungrounded supply conductor. Voltage and current ratings as recommended by ballast manufacturer. Fuses shall be installed in handhole near base of pole, not at fixture head.
- M. Occupancy Sensor: When occupancy sensor on the fixture is specified, the fixture shall be equipped with an integral passive infrared occupancy sensor device that changes the light level by dimming the light engine.
  - 1. The sensor shall also have the capability of providing ambient light sensing and adjusting light levels accordingly.
  - 2. The sensor shall have an adjustable time delay feature.
  - 3. The low and high dimming shall be field adjustable.

# 2.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay.
  - 1. Relay with locking-type receptacle shall comply with ANSI C136.10.
  - 2. Adjustable window slide for adjusting on-off set points.

# 2.5 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4-M.
  - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
  - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
  - 1. Materials: Shall not cause galvanic action at contact points.

- 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
- 3. Anchor-Bolt Template: Plywood or steel.
- D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.
- E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

# 2.6 STEEL POLES

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
  - 1. Shape: Square, straight.
  - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as pole.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
  - 1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with stainless-steel bolts.
  - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
  - 3. Match pole material and finish.
- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet (3 m) above finished grade.
- F. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.
- G. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

- H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- I. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.
- J. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- K. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.
- L. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
  - 2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
  - 3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
    - a. Color: As selected by Architect from manufacturer's full range.

# 2.7 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
  - 1. Shape: Square, straight.
  - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
  - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
  - 2. Finish: Same as luminaire.
- F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

- G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
  - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
  - 3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
  - 4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
    - a. Color: As selected by Architect from manufacturer's full range.

# 2.8 PRESTRESSED CONCRETE POLES

- A. Poles: Manufactured by centrifugal spin-casting process.
  - 1. Shape: Square, straight.
  - 2. Mounting Provisions: Steel butt flange for bolted mounting to foundation or breakaway support.
  - 3. Finishing: Capped at top and plugged at bottom. Seat each steel reinforcing strand with epoxy adhesive.
  - 4. Grounding: Continuous copper ground wire cast into pole. Terminate at top of pole.
- B. Cure with wet steam and age for a minimum of 15 days before installation.
- C. Fabricate poles with a hard, nonporous surface that is resistant to water, frost, and road and soil chemicals and that has a maximum water-absorption rate of 3 percent.
- D. Cast aluminum nameplate into pole wall at approximately 5 feet (1.5 m) above ground line, listing name of manufacturer, Project identifier, overall height, and approximate weight.
- E. Pole Brackets: Comply with ANSI C136.13.
- F. Finish Color: Provided by color material complying with ASTM C 979, uniformly impregnated throughout the pole concrete. Color material shall provide a uniform, stable, permanent color and be as follows:
  - 1. Inert, and carbon free.
  - 2. Unaffected by environmental conditions and contaminants including, but not limited to, UV solar radiation, salts, and alkalis.
- G. Finish Texture: Standard form.

# 2.9 POLE ACCESSORIES

A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.

- 1. Recessed, 12 inches (300 mm) above finished grade.
- 2. Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, color to match pole, that when mounted results in NEMA 250, Type 3R enclosure.
- 3. With cord opening.
- 4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
- B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
- C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

#### PART 3 - EXECUTION

- 3.1 LUMINAIRE INSTALLATION
  - A. Install lamps in each luminaire.
  - B. Fasten luminaire to indicated structural supports.
    - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
  - C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

# 3.2 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
  - 1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
  - 2. Water, Gas, Electric, Communication, and Sewer Lines: 5 feet (3 m).
  - 3. Trees: 10 feet (5 m) from tree trunk.
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
  - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
  - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.

- 3. Install base covers unless otherwise indicated.
- 4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
  - 1. Dig holes large enough to permit use of tampers in the full depth of hole.
  - 2. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
- F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
  - 1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
  - 2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days, and finish in a dome above finished grade.
  - 3. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
  - 4. Cure concrete a minimum of 72 hours before performing work on pole.
- G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
- H. Raise and set poles using web fabric slings (not chain or cable).

# 3.3 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

# 3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

### 3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

# 3.6 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
  - 1. Install grounding electrode for each pole unless otherwise indicated.
  - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
  - 1. Install grounding electrode for each pole.
  - 2. Install grounding conductor and conductor protector.
  - 3. Ground metallic components of pole accessories and foundations.

# 3.7 FIELD QUALITY CONTROL

- A. Inspect each installed unit for damage. Replace damaged units.
- B. Advance Notice: Give dates and times for field tests.
- C. Provide instruments to make and record test results.
- D. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:
  - 1. Measure light intensities at night if specific illumination performance is indicated. Use photometers with calibration referenced to NIST standards.
  - 2. Check intensity and uniformity of illumination.
  - 3. Check excessively noisy ballasts.
- E. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.
- F. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

# 3.8 CLEANING AND ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.
- B. Adjust aimable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.

END OF SECTION 26 5600

# SECTION 27 0500 - COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS

#### PART 1 – GENERAL

### 1.01 SCOPE OF WORK

- A. Base Bid: It is the intent of these specifications to provide complete and workable telecommunications systems including all parts lists, operating instructions and wiring diagrams, as shown on the accompanying plans and as specified herein except such parts as are specifically exempted herein. Provide all necessary supervision, coordination, labor, materials, equipment, fixtures, drayage, hoisting, tools, transportation, plant services and facilities, machinery and connections to utilities for the installation of complete and operable telecommunications systems. If details or special conditions are required in addition to those shown on drawings, provide all material and equipment usually furnished with such systems or required to complete their installation, whether noted in plans and specification or not.
- B. Materials and labor shall be new (unless noted otherwise), first class and workmanlike and shall be subject at all times to the A/E's inspections, tests and approval from the commencement until the acceptance of the completed work.
- C. The layout shown on the drawings is necessarily diagrammatic but shall be followed as closely as other work will permit. The drawings provide design intent. The Contractor shall verify all dimensions at the site and be responsible for their accuracy.
- D. Because of the scale of the Drawings, certain basic items, such as, pipe fittings, duct fittings, access panels, and sleeves, may not be shown. Where such items are required by Code or by other Sections, or where required for proper installation of the Work, such items shall be included, whether shown or not.
- E. In the event of any inconsistencies between the specifications, drawings, contract documents, applicable laws, statutes, ordinances, building codes, rules and regulations, the contractor shall provide the better quality or greater quantity of work and comply with or conform its work to the most stringent legal or contractual requirements.
- F. Changes from these drawings required to make this work conform to the building construction shall be made only with prior written approval of the Architect/Engineer. All proposed changes shall be shown on shop drawings. All measurements shall be verified by actual observation and all work shall fit in place meeting the approval of the Architect/Engineer.
- G. Equipment Specification may not deal individually with minute items required, such as, components, parts, controls, and devices which may be required to produce the equipment performance specified or as required to meet the equipment warranties. Where such items are required to make the system operational, they shall be included by the supplier of the equipment at no additional cost, whether or not specifically called for.
- H. Equipment, materials and accessories for communications systems as shown and noted on the drawings including but not limited to the following:
  - A complete raceway system including conduit, outlet box, pull boxes, junction boxes, sleeves and hangers. This work may be separated out for completion by the Division 26 contractor. Usually the General Prime Contractor (GPC) will assign this work to Div 26 contractor. Div 27 contractor shall confirm this arrangement prior to bidding. Otherwise Div 27 shall provide raceway as required.
  - 2. Complete structured cabling system including all riser and horizontal cables.

PROJECT NO. 18-168.00	COMMON WORK RESULTS FOR COMMUNICATIONS SY	<b>STEMS</b>
HARBORCHASE OF FARMINGTON HILLS, MI	ICHIGAN	27 0500 - 2
HRA		10/24/2019
PERMIT SET		

- 3. Communications distribution equipment including patch panels, innerduct, terminations, racks and cabinets.
- 4. Maintaining of all communications and other low voltage connections outside of or passing through the work area to other areas.
- 5. All cutting and patching to accomplish wiring tasks.
- 6. All conduit penetrations through walls and floors and complete fire stopping of penetrations per standards of a national testing laboratory.
- 7. Creation of new cable pathways through areas where no pathway currently exists.
- 8. New wiring devices, jacks and cover plates.
- 9. Complete testing, certification and creation of as-builts for all jack locations.

# 1.02 SECTION INCLUDES

- A. This section includes information common to two or more technical communications specification sections or items that are of a general nature, not conveniently fitting into other technical sections.
  - 1. Submittals
  - 2. Construction Verification Checklists
  - 3. Functional Performance Tests
  - 4. Reference Standards
  - 5. Quality Assurance
  - 6. Guarantee
  - 7. Equipment Furnished By Others
  - 8. Operation And Maintenance Instructions
  - 9. Record Documents
  - 10. Protection Of Finished Surfaces
  - 11. Sealing And Firestopping
  - 12. Off Site Storage
  - 13. Regulatory Requirements
  - 14. Certificates And Inspections
  - 15. Coordination
  - 16. Request And Certification For Payment
  - 17. Sleeves And Openings
  - 18. Omissions
  - 19. Definitions
  - 20. Project/Site Conditions
  - 21. Work Sequence And Scheduling
  - 22. Salvage Materials
  - 23. Performance Testing
  - 24. Description
  - 25. Dimensions And Define Locations
  - 26. Training
  - 27. Access Panels And Doors
  - 28. Identification
  - 29. Demolition
  - 30. Cutting And Patching
  - 31. Building Access
  - 32. Equipment Access
  - 33. Housekeeping And Clean Up
  - 34. Cable Installation

- 35. Testing
- 36. Systems Checklist
- 1.03 RELATED WORK
  - A. Applicable provisions of Division 1 govern work under this section.
  - B. This section is applies to all Division 27 sections.
  - C. Section 27 05 26 Grounding and Bonding for Communications Systems
  - D. Section 27 05 53 Identification for Communications Systems
  - E. Section 27 05 60 Communications Firestopping
  - F. Section 27 11 00 Communications Room Provisioning
  - G. Section 27 13 10 Backbone Copper Cable and Equipment
  - H. Section 27 13 20 Fiber Optic Cable and Equipment
  - I. Section 27 15 10 Horizontal Copper Cable and Equipment
  - J. This work is also subject to all requirements of Division 26 of these specifications and NFPA 70 and the National Electric Code wherever applicable to work under this section.
- 1.04 SUBMITTALS
  - A. Submit shop drawings for equipment under each section per requirements listed in that section, as well as per Division 1.
  - B. Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and proper identification of equipment by name and/or number, as indicated in the contract documents. Failure to do this may result in the submittal(s) being returned to the Contractor for correction and resubmission. Do not submit hard copies of web pages. Failing to follow these instructions does not relieve the Contractor from the requirement of meeting the project schedule.
  - C. On request from the A/E, the successful bidder shall furnish additional drawings, illustrations, catalog data, performance characteristics, etc.
  - D. Submittals shall be grouped to include complete submittals of related systems, products, and accessories in a single submittal. Mark dimensions and values in units to match those specified. Include wiring diagrams of electrically powered equipment.
  - E. The submittals must be approved before fabrication is authorized.
  - F. Provide electronic copies of all submittals for review.

# FUNCTIONAL PERFORMANCE TESTS

A. Contractor is responsible for creating and performing functional test procedures to assure the proper functioning of every system provided.

#### 1.05 REFERENCE STANDARDS

- A. Abbreviations of standards organizations referenced in this and other sections are as follows:
  - 1. ANSI American National Standards Institute
  - 2. ASTM American Society for Testing and Materials
  - 3. EPA Environmental Protection Agency
  - 4. ETL Electrical Testing Laboratories, Inc.
  - 5. IEEE Institute of Electrical and Electronics Engineers
  - 6. IES Illuminating Engineering Society
  - 7. ISA Instrument Society of America
  - 8. NBS National Bureau of Standards

PROJECT NO. 18-168.00 COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 27 0500 - 4 HRA 10/24/2019 PERMIT SET

- 9. NEC National Electric Code
- 10. NEMA National Electrical Manufacturers Association
- 11. NESC National Electrical Safety Code
- 12. NFPA National Fire Protection Association
- 13. UL Underwriters Laboratories Inc.

# 1.06 QUALITY ASSURANCE

A. Substitution of Materials: Refer to Division 1 for equals and substitutions.

- 1. Where the following conflicts with Division 1, the requirements of Division 1 shall govern.
- 2. If the Contractor wishes to submit an alternate to the named manufacturers for any equipment, he may submit a voluntary alternative minimum 7 days prior to bid, stating the manufacturer's name, model number, written, detailed product data.
- 3. Where materials or equipment are specified by name the proposed material or equipment must be identical to the specified material or equipment in all characteristics of quality, function and serviceability, regardless of application in the Project and, in addition, when the Architect deems that aesthetic significance is important, the equal material or equipment must be identical in all characteristics of visual appearance, design, color and texture. Any proposed equal shall be submitted to Architect/Engineer for prior approval, which Architect/Engineer may approve or disapprove in its sole discretion. Work performed or constructed with unapproved equals is at Contractor's risk and any required correction of work incorporating unapproved equals shall be at Contractor's sole cost and expense.
- 4. In all instances, Contractor shall assume full responsibility for proof of equality of the statute to the equipment hereinafter specified. All data and information necessary for proof of equality, function and space requirements shall be prepared and accompany the submittal of the substitution to the Architect/Engineer. Approval by the Architect/Engineer of equipment other than the specified does NOT relieve Contractor of this responsibility.
- B. All products and materials used are to be new, undamaged, clean and in good condition. Existing products and materials are not to be reused unless specifically indicated.
- C. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system, including, but not limited to, coordination with other trades and any required changes by other trades and for obtaining the intended performance from the system into which these items are placed.
- D. General:
  - 1. Cable and Equipment Manufacturer(s) shall be a company specializing in communications cable, accessories and/or equipment with minimum of 5 years documented experience in producing cable, accessories and/or equipment similar to those specified herein.
- E. Contractor Qualifications:
  - 1. Qualified personnel utilizing state-of-the-art equipment and techniques shall complete all cable and equipment installation and termination.
  - 2. Contractor shall have been in this business for minimum of 5 years and completed 4 projects of magnitude specified in the following sections.
  - 3. Contractor shall be certified by the cabling/connectivity manufacturer to install the products provided.
  - 4. See Appendix A for complete qualifications.
- F. Cable Systems:
  - 1. Cable and connection hardware (fiber optic and copper) shall be qualified by Contractor and Manufacturer(s) as certified cabling system. Refer to manufacturers' recommendations for

appropriate component types. Contractor shall install and test cable to meet all performance criteria and complete all documentation required by manufacturer in order to obtain cabling system warranty (performance warranty certification). Contractor shall obtain warranty from manufacturer within 30 days of substantial completion and provide a copy of approved warranty to the engineer, the original to the owner.

2. Provide as-built jack label documentation indicating actual locations and labels of all station jacks, changes in cable schedules and changes in rack mounted equipment. See specifications for other labeling requirements.

# 1.07 GUARANTEE

- A. Refer to Division 1 for Guarantees and Warranties. In addition to the requirements in Division 1, this Contractor shall meet the following requirements.
- B. In entering into a contract covering this work, the contractor accepts the specifications and guarantees that the work will be carried out in accordance with the requirements of this specification or such modifications as may be made under the contract documents.
- C. Contractor further guarantees that the workmanship and material will be of the best procurable and that none but experienced workmen familiar with each particular class of work will be employed.
- D. Contractor further guarantees to replace and make good at his own expense, including travel time, all defects, which may develop within 1 year after final payment and acceptance by the Architect/Engineer, due to faulty workmanship or material, upon, receipt of written notification from the Owner.
- E. Manufacturer(s) of cabling and connectivity system shall warranty materials, equipment, and performance etc. for minimum of 20 years from date of substantial completion of work. Warranty shall include labor, material and travel time.

# 1.10 OPERATION AND MAINTENANCE INSTRUCTIONS

- A. Refer to Division 1 for all operations and maintenance instructions.
- B. In addition to the general content specified under Division 1 supply the following additional documentation:
  - 1. Copies of all approved submittals along with approval letters
  - 2. Certificates
  - 3. Warranties
  - 4. Operation manual documents to assist the Owner to maintain all systems
  - 5. Records of test performed to certify compliance with system and manufacturer requirements
  - 6. Full equipment cut sheets including brands, makes, models, supplier (retailer) and manufacturer information (name, phone, e-mail, website, contact name), one-line diagrams, cable connections, system architecture
  - 7. Contractor information (name, phone, e-mail, website, contact name)
  - 8. Systems checklist (refer to Part 3 below)

# 1.11 RECORD DOCUMENTS

- A. Refer to Division 1 for record documents.
- B. In addition to the general content specified under Division, follow the following procedures.
  - 1. During the progress of the work, Contractor shall maintain a current (daily) record set of the drawings and specifications, indicating thereon all work installed at variance with such Contract Documents including, without limitation, work covered by Addenda, Field Work Orders, Change Orders and Engineers additional instructions, interpretations and clarification. All changes or deviations from the original layout of the work and all critical dimensions of buried or concealed work shall be recorded. It shall be Contractor's responsibility to assure that said record sets are

complete, accurate and up-to-date, Engineer shall have the right to inspect and review such record sets.

- 2. At the completion of the work, Contractor shall indicated on record sets all record changes and such additional details necessary or appropriate to provide a complete reference document for use by Engineer. If variations and details cannot be shown clearly thereon, the Contractor shall prepare supplemental drawings adequate to impart the information. The foregoing drawings collectively shall constitute the "Record" drawings for the work.
- 3. All indication on "Record" drawings shall be executed in a legible manner at Contractor's cost, using methods and legend presentations compatible with the overall scheme of the record drawings with respect to scale, drawing sheet sizes and sequential indexing. All changes shall be marked clearly in red and clouded.
- 4. Engineer may review Contractor's "Record" drawings and notify Contractor of observed discrepancies or deviations. Contractor shall promptly correct discrepancies, deviations or illegible markups at Contractor's expense and resubmit revised drawings for Engineer review.
- 5. Contractor shall provide final electronic record drawings to the Owner through the Engineer.

# 1.12 PROTECTION OF FINISHED SURFACES

- A. Refer to Division 1 for protection of finished services.
- B. Furnish one can of touch-up paint for each different color factory finish furnished by the Contractor. Deliver touch-up paint with other "loose and detachable parts" per Division 1.

# 1.13 SEALING AND FIRESTOPPING

- A. Sealing and firestopping of sleeves/openings between conduits, cable trays, wireways, troughs, cablebus, busduct, etc. and the structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and firestopping. These individuals hired shall normally and routinely be employed in the sealing and fireproofing occupation.
- B. Contractor shall request current life safety drawings from the Architect/Owner.

# 1.14 OFFSITE STORAGE

A. If payment will be requested for approved offsite stored material, then the Contractor shall complete an "Off-site Storage Agreement" which is available from the Owner. Prior approval by Owner's personnel for offsite storage will be needed. No material will be accepted for offsite storage unless submittals for the material have been approved.

# 1.15 REGULATORY REQUIREMENTS

A. Comply with requirements of Wisconsin Administrative Code and local Authority Having Jurisdiction (AHJ) regarding materials and installation.

# 1.16 CERTIFICATES AND INSPECTIONS

- A. Refer to Division 1 for permits, regulations, utilities and taxes.
- B. Obtain and pay for all required State or local installation inspections except those provided by the Architect/Engineer in accordance with State Code. Deliver originals of these certificates to the Owner. Include copies of the certificates in the Operating and Maintenance Instructions.
- C. Coordinate and provide inspections as required by the Authority Having Jurisdiction over the site.
- 1.17 COORDINATION

## PROJECT NO. 18-168.00 COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 27 0500 - 7 HRA 10/24/2019 PERMIT SET

- A. Refer to Division 1 for coordination. In addition to the requirements specified under Division 1, the following requirements apply.
- B. It shall be the responsibility of each Contractor to coordinate and consult with each other to determine space requirements and to determine that adequate space for servicing is provided for all equipment whether furnished by the Contractor or others. The General Contractor shall have final decision on all space priority conflicts among Contractors. All space priority conflicts shall be brought to the attention of the Architect/Engineer and Owner's Representative.
- C. Each Contractor shall thoroughly familiarize himself with existing systems which will affect and be affected by relocation of existing equipment and installation of new lines and equipment. They shall plan installation of their work so that interruptions of services to any building or portion thereof will be a minimum, and such interruptions shall occur only when system is not required, if possible. If not possible, each Contractor shall insure the operation of services by whatever means possible, such as, installing bypasses, capping of services, or providing temporary service. Each interruption shall be for as short a duration as possible.
- D. In the case of interconnection of the work of two or more contractors, verify at the site or on shop drawings all dimensions relating to such work. All errors due to the failure to so verify any such dimensions shall be promptly rectified.
- E. Any installed work that is not coordinated and interferes with another contractor's work shall be removed or relocated at the installing contractor's expense.
- F. Within a period not to exceed two weeks after distribution of the drawings, the

# 1.18 REQUEST AND CERTIFICATION FOR PAYMENT

- A. Within 10 days after Notice to Proceed, the successful bidder will submit to the Owner's Project representative in a form prescribed by Division 1, a cost breakdown of the proposed values for work performed which, if approved by the Owner's project representative, will become the basis for construction progress and monthly payments. The cost breakdown items shall reflect actual work progress stages as closely as feasible.
- B. In addition, if payment will be requested for approved off-site stored material, then that material shall be listed as a line item in the request and certification for payment cost breakdown.

# 1.19 SLEEVES AND OPENINGS

A. Openings required in new or existing construction that may be necessary for the installation of new work shall be provided by the respective contractor and all patching and repairing shall be done by workmen competent in the trade required, at the expense of the respective contractor. The respective contractor shall be responsible for arranging the work so that minimum cutting will be required. All rubbish and excess materials involved in such cutting shall be promptly removed from the site and disposed of by the contractor. Cutting through the floor or roof systems or load bearing walls shall be done only with the prior written approval of the Architect/Engineer so as to avoid damaging the structural system.

# 1.20 OMISSIONS

- A. No later than ten (10) days before bid opening, the Contractor shall call the attention of the A/E to any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.
- B. Where local or national codes apply, the contractor shall provide all devices necessary to meet the code, regardless of whether they are indicated on the prints or not.
  - a. The Contractor shall price in his bid and provide all such devices as required by code. If there is any question regarding any device, the contractor shall submit an official RFI (request for

information) through official channels prior to the bid date. If no RFI is provided by the contractor and no answer is given by the engineer, the contractor shall provide all such devices required to meet code and include those devices in the bid price.

- 1.21 DEFINITIONS
  - A. Backbone Cabling Cables connecting TRs from lower level to upper level or between TRs. Term also applies to outside plant cabling between buildings.
  - B. BEF Building Entrance facility Voice, data and video services are brought from the street into building in this room.
  - C. Cable Assembly of one or more conductors or optical fibers within enveloping sheath, constructed so as to permit use of conductors singly or in groups.
  - D. Cable Link Includes SIO, station cable and termination hardware in TR.
  - E. Cable Channel Same as Cable Link, plus patch cords at SIO and in TR.
  - F. Consolidation Point Also known as zone distribution box (ZDB). Intermediate point having multiple terminations between SIO and TR to simplify moves, adds and changes, bringing final terminations closer to SIOs.
  - G. Cross-Connect Group of connection points, wall or rack mounted, used to mechanically terminate and administer building wiring.
  - H. Entrance Room (ER) A combination of BEF and MDF in one room. All building voice, data and video services are distributed to TRs on all levels from this room. Cables to all outlying campus buildings are terminated and distributed from the ER. ERs are on floor 2.
  - I. Faceplate a covering placed over a recessed back box that contains one or more openings to house individual jacks.
  - J. Horizontal Cabling Cables connecting SIOs to TRs.
  - K. Jack a single outlet consisting of a single connector attached to a single cable assembly. Multiple jacks may be installed into a single faceplate.
  - L. MDF Main Distribution Frame Same as BEF or ER.
  - M. OFCI Owner furnished, contractor installed.
  - N. OFOI Owner furnished, owner installed
  - O. CFCI Contractor furnished, contractor installed
  - P. OSP Outside Plant (refers to equipment, conduit and installation contractor provided under separate contract to provide equipment beyond five feet from B2 building foundation.
  - Q. The term "provide" includes such labor, methods, materials, equipment and transportation or other facilities required to complete the Contract and the performance of all duties thereby upon the Contractor.
  - R. RU Rack Unit Each RU is 1.75" high.
  - S. SIO Standard Information Outlet A device assembly located in work area on which horizontal cabling terminates and which can receive modular connectors. Depending on the immediate context, an SIO may refer to either a faceplate configuration (i.e., an SIO having two standard data jacks SIO = faceplate) or in other cases may refer to a single jack (i.e. SIO = one jack). In some cases, as in item T below, the distinction is irrelevant.
  - T. Telecommunications Any transmission, emission, or reception of signs, signals, writings images, sounds or information of any nature by wire, radio, visual, optical or other electromagnetic systems.
  - U. TR Telecommunications Room Room used to cross connect backbone cable to horizontal station cable out to SIOs. May house network electronics. Also houses equipment for other systems such as CCTV and Access Control. Interchangeable with term IDF (Intermediate Distribution Facility). Usually one per floor to accommodate SIOs on that same floor.

- V. MTR Main Telecommunications Room Same as IDF but usually larger and located on a lower floor to consolidate riser cables from multiple TRs. May also function as a building entrance facility to receive cables from outside service providers. Interchangeable with term MDF (Main Distribution Facility).
- W. UTP Unshielded Twisted Pair Cabling

# 1.22 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of A/E before proceeding.
- C. Tools, materials and equipment shall be confined to areas designated by the Owner's project representative.

# 1.23 WORK SEQUENCE AND SCHEDULING

- A. Install work in phases to accommodate Owner's occupancy requirements. During the construction period coordinate schedule and operations with Owner's Construction Representatives.
- 1.24 SALVAGE MATERIALS
  - A. No materials removed from this project shall be reused (except as specifically noted below). All materials removed shall become the property of and shall be disposed of by the Contractor.

# 1.25 PERFORMANCE TESTING

- A. Each system included in project scope shall be tested to verify performance.
- B. Systems that require a performance warranty (such as data cable) shall be tested to comply with manufacturer's requirements in order to obtain the system warranty.
- C. Some systems have specific testing procedures (fiber optic cable).
- D. Systems not having specific testing criteria shall utilize the Systems Checklist described in Part 3 below.

# 1.26 DESCRIPTION

- A. Structured cabling system is a complete collective configuration of cabling and associated hardware on a premises which, when installed, provides a comprehensive telecommunications infrastructure. Systems shall include backbone and station data, voice, and video and fiber optic cable as indicated on drawings.
- B. Cables and equipment shall be provided, tested, and terminated, including proper grounding and bonding.
- C. Voice Service is carried on copper cable, backbone data services are carried on fiber optic cable, and television service is carried on coaxial cable and copper cable.
- D. Telecommunication distribution consists of Telecommunications Rooms (TR), fiber optic backbone, category 3 or voice grade copper backbone, category 6 copper data station cable, wall and floor box outlets, cable tray and conduit.
- E. TRs are located throughout facility.
- F. No UTP station cable link shall be longer than 90 meters.
- G. Cabling to be plenum rated where noted and where environment dictates plenum rated cabling.
- H. Systems shall be delivered in complete functioning condition.
- I. Coordinate with owner as required to obtain owner furnished items.
- 1.27 DIMENSIONS AND DEFINITE LOCATIONS

- A. The Drawings depicting Work show approximate locations. The exact location of equipment and devices shall be established in the field in accordance with instructions from the Owner. Consideration shall be given to construction features, equipment of other trades, and requirements of the equipment proper.
- B. The Contractor shall refer to Shop Drawings and submittal drawings for all equipment requiring electrical connections to verify rough-in and connection locations.
- C. Unless specifically stated to the contrary, no Drawing by scale shall be used as a dimension to Work by. Dimensions noted on the Drawings are subject, in each case, to measurements of adjacent or previously completed Work and all such measurements necessary shall be taken before undertaking any Work dependent upon them.

# 1.28 TRAINING

- A. The contractor shall have the following responsibilities:
  - 1. Provide a training plan thirtty days before the planned training covering the following elements:
    - a. Equipment
    - b. Intended audience
    - c. Location of training
    - d. Objectives
    - e. Subjects covered (description, duration of discussion, special methods, etc.)
    - f. Duration of training on each subject
    - g. Instructor for each subject
    - h. Methods (classroom lecture, manufacturer's quality video, site walk-through, actual operational demonstrations, written handouts, etc.).
  - 2. Provide designated owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of equipment that makes up the system.
  - 3. Training shall normally start with classroom sessions followed by hands-on demonstration/training on each piece of equipment.
  - 4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system shall be repaired or adjusted as necessary and the demonstration repeated at another scheduled time, if necessary.
  - 5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
  - 6. The controls contractor shall attend sessions other than the controls training, as specified, to discuss the interaction of the controls system as it relates to the equipment being discussed.
  - 7. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
  - 8. Training shall include:
    - a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
    - b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include startup, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.
    - c. Discussion of relevant health and safety issues and concerns.
    - d. Discussion of warranties and guarantees.

- e. Common troubleshooting problems and solutions.
- f. Explanatory information included in the O&M manuals.
- g. Discussion of any peculiarities of equipment installation or operation.
- h. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
- i. Hands-on training shall include startup, operation in all modes possible, including manual, shut-down, alarms, power failure and any emergency procedures, and preventative maintenance for all pieces of equipment.
- 9. The contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls not controlled by the central control system.
- B. Video recording of the training sessions will be provided by the contractor and added to the O&M manuals. In addition, factory training videos identifying key troubleshooting, repair, service and/or replacement techniques shall be provided and reviewed with the owner.
- C. Provide a minimum of 8 hours of instruction.
- D. Provide additional training as specified in other specification sections for specific equipment.

# PART 2 – PRODUCTS

# 2.01 ACCESS PANELS AND DOORS

- A. Lay-In Ceilings:
  - 1. Removable lay-in ceiling tiles in 2 x 2 foot or 2 x 4 foot configuration provided under Division 9 are sufficient; no additional access provisions are required unless specifically indicated.
- B. Concealed Spline Ceilings:
  - 1. Removable sections of ceiling tile held in position with metal slats or tabs compatible with the ceiling system used will be provided under Division 9.
- C. Metal Pan Ceilings:
  - 1. Removable sections of ceiling tile held in position by pressure fit will be provided under Division 9.
- D. Plaster Walls and Ceilings:
  - 16 gauge frame with not less than a 20 gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers and similar wet areas, concealed hinges, screwdriver operated cam latch for general application, key lock for use in public areas, UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the equipment needing service; minimum size is 12" by 12".
  - 2. In the case of E-Call systems, plastic access panels may be used with permission of architect.

# 2.02 IDENTIFICATION

A. Refer to Section 27 05 53 – Identification for Communication Systems.

# 2.03 SEALING AND FIRESTOPPING

- A. Refer to section 27 05 60
- B. Fire And/Or Smoke Rated Penetrations:
  - 1. Manufacturers:
    - a. 3M, STI/SpecSeal, Tremco, Hilti
    - b. All firestopping systems shall be by the same manufacturer.
  - 2. Submittals:

- a. Contractor shall submit product data for each firestop system. Submittals shall include product characteristics, performance and limitation criteria, test data, MSDS sheets, installation details and procedures for each method of installation applicable to this project. For non-standard conditions where no UL tested system exists, submit manufacturer's drawings for UL system with known performance for which an engineering judgment can be based upon.
- 3. Product:
  - a. Firestop systems shall be UL listed or tested by an independent testing laboratory approved by the Owner and the Authority Having Jurisdiction (AHJ).
  - b. Use a product that has a rating not less than the rating of the wall or floor being penetrated. Reference architectural drawings for identification of fire and/or smoke rated walls and floors.
  - c. Contractor shall use firestop putty, caulk sealant, intumescent wrapstrips, intumescent firestop collars, firestop mortar or a combination of these products to provide a UL listed system for each application required for this project. Provide mineral wool backing where specified in manufacturer's application detail.
  - d. All sealants shall meet the intent of LEED® VOC requirements, <250 g/L VOC contents (less H<sub>2</sub>0 and exempt solvents).
- C. Non-Rated Penetrations:
  - 1. Conduit Penetrations Through Below Grade Walls:
    - a. In exterior wall openings below grade, use a modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the uninsulated conduit and the cored opening or a water-stop type wall sleeve.
  - 2. Conduit and Cable Tray Penetrations:
    - a. At conduit and cable tray penetrations of non-rated interior partitions, floors and exterior walls above grade, use urethane caulk in annular space between conduit and sleeve, or the core drilled opening.

# PART 3 - EXECUTION

# 3.01 CUTTING AND PATCHING

- A. Refer to Division 1 for cutting and patching. In addition to the requirements in Division 1:
- B. Each Contractor shall coordinate the placing of openings in the new structure as required for the installation of each Contractor's work.
- C. Each Contractor shall furnish to the General Contractor the accurate locations and sizes for required openings in the new work, but this shall not relieve each Contractor of the responsibility of checking to assure that properly sized openings are provided. When additional patching is required due to the Contractor's failure to inspect this work, then the Contractor shall make arrangements for the patching required to properly close the openings to include patch painting, and the Contractor shall pay any additional cost incurred in this respect.
- D. If cutting and patching of the new structure is made necessary due to the Contractor's failure to install piping, ducts, sleeves, or equipment on schedule, or due to the Contractor's failure to furnish on schedule the information required for the leaving of openings, then it shall be the Contractor's responsibility to make arrangements and obtain approval from the General Contractor and Architect/Engineer for this cutting and patching, and the Contractor shall pay any additional costs incurred in this respect. The Contractor shall also reimburse the Owner for any additional costs incurred to the Architect/Engineer for additional services caused by the Contractor in this respect.
- E. The Contractor shall provide cutting and patching and patch painting in the existing structure as required for the installation of his Work and shall furnish lintels and supports as required for openings.

Cutting of structural support members will not be permitted without prior approval of the Architect/Engineer. Extent of cutting shall be minimized; use core drills, power saws, or other machines which will provide neat, minimum openings. Patching shall match adjacent materials and surfaces and shall be performed by craftsmen skilled in the respective craft required.

### 3.02 BUILDING ACCESS

A. Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

#### 3.03 EQUIPMENT ACCESS

A. Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Where access is required in plaster or drywall walls or ceilings, furnish the access doors to the General Contractor and reimburse the General Contractor for installation of those access doors.

# 3.04 COORDINATION

- A. The Contractor shall cooperate with other trades in locating work in a proper manner. Should it be necessary to raise or lower or move longitudinally any part of the electrical work to better fit the general installation, such work shall be done at no extra cost to the Owner, provided such decision is reached prior to actual installation. The Contractor shall check location of electrical outlets with respect to other installations before installing.
- B. The Contractor shall verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to light fixtures, panelboards, devices, etc. and recessed or semirecessed heating units installed in/on architectural surfaces. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls and other structural components as they are constructed.
- C. Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.
- D. Coordinate with Division 27 and 28 contractors and equipment vendors for proper location, quantity and capacity of all required conduits, back boxes, device rings and power supplies required to support systems specified.

# 3.05 SEALING AND FIRESTOPPING

- A. The Contractor shall refer to building life safety drawings for all smoke and fire rates in addition to the mechanical drawings. Any discrepancies shall be brought to the attention of the Architect/Engineer before final addendum.
- B. Fire and/or Smoke Penetrations:
  - 1. Install approved product in accordance with the manufacturer's instructions where a pipe (i.e. cable tray, bus, cable bus, conduit, wireway, trough, etc.) penetrates a fire rated surface.
  - 2. Where firestop mortar is used to infill large fire-rated floor openings that could be required to support weight, provide permanent structural forming. Firestop mortar alone is not adequate to support any substantial weight.
- C. Non-Rated Surfaces:
  - 1. When the opening is through a non-fire rated wall, floor, ceiling or roof the opening must be sealed using an approved type of material.

- Install escutcheons or floor/ceiling plates where conduit, penetrates non-fire rated surfaces in occupied spaces. Occupied spaces for this paragraph include only those rooms with finished ceilings and the penetration occurs below the ceiling.
- 3. In exterior wall openings below grade, assemble rubber links of mechanical seal to the proper size for the conduit and tighten in place, in accordance with the manufacturer's instructions. Install so that the bolts used to tighten the seal are accessible from the interior of the building or vault.
- 4. At interior partitions, conduit penetrations are required to be sealed for all clean rooms, laboratories, and most hospital spaces, computer rooms, dormitory rooms, tele/data/com rooms and similar spaces where the room pressure or odor transmission must be controlled. Apply sealant to both sides of the penetration in such a manner that the annular space between the conduit sleeve and the conduit is completely filled.

# 3.06 HOUSEKEEPING AND CLEAN UP

A. The Contractor shall clean up and remove from the premises, on a daily basis, all debris and rubbish resulting from its work and shall repair all damage to new and existing equipment resulting from its work. When job is complete, this Contractor shall remove all tools, excess material and equipment, etc., from the site.

# 3.07 CABLE INSTALLATION

- A. Furnish all required installation tools to facilitate cable pulling without damage to cable jacket.
- B. During pulling operation adequate number of workers shall be present to allow cable observation at all points of raceway entry and exit, as well as to feed cable and operate pulling machinery.
- C. Pull cables in accordance with cable manufacturer's recommendations and ANSI/EEE C2 Standards.
- D. Recommended pulling tensions and bending radii shall not be exceeded.
- E. Any cables bent or kinked to radius less than recommended dimension are not allowed and shall be replaced at no expense to Owner.
- F. Pull all cable by hand unless installation conditions require mechanical assistance.
- G. Where mechanical assistance is used, ensure that maximum tensile load for cable is not exceeded. This may be in the form of continuous monitoring of pulling tension, use of "break-away" or other approved method.
- H. Install cable in conduit or metal raceway system (cable tray or equivalent) in public areas and as designated on plans. Certain routes may require cable to be run outside of cable tray.
- I. All routing shall be kept clear of other trades work and supported utilizing j-hooks.
- J. J-hook cable supports shall be installed in accordance with manufacturers' installation requirements.
- K. Provision of j-hooks is not indicated on drawings. Contractor is responsible to provide j-hooks along any route where cable tray or conduit is not available. Change orders for j-hooks will not be accepted even if cable routes must change due to lack of cable tray, avoidance of structures or other utilities or route changes due to cable length problems. All jack symbols shall assume provision of cable support including j-hooks, cable tray or conduit.
- L. Change orders for additional j-hooks, conduits or cable tray will not be accepted for route changes or changes in cable length unless pre-authorized by engineer.
- M. Cable should be provided within cable tray wherever possible and practical. Cable tray may be indicated on project documents along major routes only. Some cable may need to take alternate routes outside of cable tray to reach destination in order to stay within the cable length limit. Where installed cable does not follow cable tray, contractor shall plan for all required j-hooks and sleeves to accommodate alternate routes. Example: during bidding contractor assumes certain cables will follow cable tray route. But during installation it is discovered that route causes cable to be over the length limit, forcing another route. The alternate route requires additional J-hooks and sleeves that were not

planned during bidding. Since neither the owner nor engineer provide explicit directions for routing of every cable, and since the project scope or jack quantity did not change, the contractor shall take responsibility for measuring and planning of all cable routes and provision of all support and sleeve devices as required without incurring additional charges to the project.

- N. Spacing of J-hook cable supports shall be minimum every 4 ft. or in accordance with cable manufacturers' specifications, whichever distance is shorter. Under raised floor provide every 2 ft. or on every vertical support.
- O. J-hook fill capacities shall be:
  - 1. 1" diameter, 16 UTP 4 pair cables.
  - 2. 2" diameter, 50 UTP 4 pair cables.
  - 3. 4" diameter, 80 UTP 4 pair cables.
- P. Cable in MDF/TR shall be routed and supported utilizing "D-type" mounting rings, J-hooks and overhead cable runway.
- Q. Use of circular bridle rings made of round stock is not acceptable for cable support. Any support device must have a flat bottom (such as j-hooks) to adequately support cable without deforming cable at point of support.
- R. Repair damage to interior spaces caused by installation of cable, raceway or other hardware, Repairs must match preexisting color and finish of walls, floors and ceilings.
- S. Replace contractor-damaged ceiling tiles to match color, size, style and texture.
- T. Avoid abrasion and other damage to cables during installation. Any cable having visible abrasions that have worn through the outer sheath shall be replaced at contractor's expense, whether the cable passes the certification test, or not.
- U. Provide plastic bushings on the end of every conduit or sleeve that is utilized for cable. Use of conduits or sleeves WITHOUT the provision of plastic bushings to protect the end of the conduit may be cause for removal and replacement of all cables utilizing that conduit or sleeve.
- V. Pulling lubricant may be used and shall:
  - 1. Be non-injurious to cable jacket and other materials used.
  - 2. Not harden or become adhesive with age.
- W. Pull cord (200 lb. minimum) shall be installed with cable installed in conduit and innerduct.
- X. Provide to Engineer, prior to installation, drawings showing proposed installation for approval.
- Y. Install cables splice-free unless otherwise specified.
- Z. Cabling shall be neatly laced, dressed and supported.

# 3.08 TESTING

- A. Contractor shall:
  - 1. Submit schedule for acceptance testing. Representatives of Owner and/or Engineer may witness test procedures.
  - 2. Notify Owner and Engineer a minimum of 2 days in advance to allow for such participation.
  - 3. Conduct tests during course of construction when identifiable portion of installation is complete. Alternatively, testing can be conducted after entire installation is complete if this does not delay the project schedule.
  - 4. Describe test procedures prior to testing and submit sample test form to Engineer. Submit 3 record copies, and one electronic copy in CSV format, of results of tests to Engineer for approval.
  - 5. Alternatively, Contractor may submit proprietary electronic format test results, including software to access and print results. Software shall be Windows™ compatible.
- B. Testing shall be completed and accepted by Owner and Engineer before Owner furnished equipment and cross connects are installed.

- C. Test results shall be provided to manufacturer in order to obtain complete cable system warranty within 30 days of project completion. Provide original warranty certificate to owner and one copy to engineer.
- D. Provide as-built jack plans and other as-built documentation as determined by field labeling or other changes to project documents.
- E. The contractor is responsible to assure that all individual components and integrated systems (especially electronic systems) are fully functioning and in good working order before notifying Engineer or Owner for acceptance testing, inspection or final punch list completion.

# 3.09 SYSTEMS CHECKLIST

- A. For all systems having an electronic equipment component (active electronics) a system checklist shall be developed and utilized by the contractor.
- B. The systems checklist shall make note of all major electronic components and systems.
- C. It shall utilize a simple method to make notations of the equipment, that they
  - 1. Function individually as designed
  - 2. Have been calibrated or adjusted
  - 3. Function as an integrated system with other components
- D. The checklist shall be utilized in the field by the contractor and filled out appropriately prior to contracting owner or engineer to witness tests, provide inspections or complete final punch list.
- E. The checklist shall have a signature line for three entities: Contractor/supervisor, owner and engineer.
- F. A completed, signed checklist (by Contractor) shall be presented to the engineer prior to performing the punch list and prior to final owner sign-off or project completion.
- G. Examples of systems that might require a checklist: Access Control, Closed Circuit TV system (security cameras), Audio-Visual systems, Area of Rescue, Digital Signage, Nurse Call and other system that utilizes active electronics.
- H. It is the responsibility of the Contractor, not the Engineer or Owner, to assure that all systems function according to the design intent of the project documents and according to all manufacturer's recommendations prior to project completion. The Systems Checklist shall be utilized by the Contractor and presented to the Engineer or Owner as verification that all systems have been tested, adjusted and are in good working order.
- I. The Systems Checklist shall be included as part of the Operations and Maintenance manual to be submitted at project completion.

END OF SECTION

# APPENDIX A

### COMMUNICATION QUALIFICATION REQUIREMENTS

#### TABLE OF ARTICLES

- 1. GENERAL
- 2. TECHNICIAN/INSTALLER QUALIFICATIONS
- 3. CONTRACTOR QUALIFICATION REQUIREMENTS

# COMMUNICATIONS QUALIFICATION REQUIREMENTS

#### ARTICLE 1 - GENERAL

- 1.1 GENERAL
  - 1.1 This document specifies the minimum technical qualifications required of Communications Subcontractors and Technicians participating in the construction this project.
  - 1.2. This document is part of the Contract Documents. The Communications subcontractor acknowledges that all Technicians performing communications work on the Project meet the technical qualifications specified herein. This document will serve as a metric to evaluate quality control and quality of work throughout the Project, including workmanship, code and standards compliance, methods, practices, accuracy of work, efficiency, and other trade related work items.
  - 1.3 The Communication Subcontractor must be able to demonstrate the capacity to satisfy all sections of this qualification document. The Owner reserves the right to require supporting documentation from the Communications subcontractor to verify that all qualification requirements specified herein for participation on the Project have been met.

# 1.2 CONTRACTORS AND SUBCONTRACTORS

1.2.1 The minimum work anticipated for the Project includes Communications cable installation, termination, documentation, labeling and testing.

# 1.3 SCOPE OF WORK

.1

- 1.3.1 In brief the Project requires:
  - Communications cabling work may include any combination of the following: new copper and optical fiber backbone cable throughout the facility; new horizontal cabling to work area outlets; and termination, labeling, and testing of new communication cabling infrastructure. New cabling will be terminated in either existing or new Telecommunication Rooms (TRs).
  - .2 Service activation work includes activating new circuits in a very methodical, organized, pre-planned, and logical approach, for both voice and data services. Activation records may be provided by the Owner. Refer to Part 1 General for scope of project. Service activation is often carried out by owner.
- 1.4 OWNER FURNISHED MATERIALS

- 1.4.1 The Owner will furnish and install all electronic voice and data equipment (Switches, routers, etc.)
- 1.4.2 The Contractor shall provide all other materials not furnished by the Owner including all horizontal UTP cable, all Coax cabling and compression fittings, all optical-fiber backbone cable, all termination hardware, both at the (WAO) work area outlet location (faceplates, Jacks, F-connector modules, blanks, labels, icons) and at the (TR) telecommunication room (termination blocks, frames, rod-mounts, jumper wire, relay racks, fiber termination hardware, panels, and connectors, multi-pair copper backbone cable, ground bars, bonding conductors, fasteners, supporting devices, cable ties, ladder rack, conduit, raceway, and other items not identified here but required for complete installation).

# ARTICLE 2 – TECHNICIAN/INSTALLER QUALIFICATION

- 2.1 General
  - 2.1.1 Technician/Installer qualification requirements are those required of Technician/Installer within the trade(s) under which they are participating on the Project.
  - 2.1.2 The qualification requirements are the minimum requirements.
  - 2.1.3 The categories below define the general scope of work by function. The category is not exhaustive of the work details.
  - 2.1.4 Qualification requires that all of the items in the category are satisfied.
- 2.2 Communications Cabling Work
  - 2.2.1 Communications cabling work includes installation, termination, and testing of multi-pair copper communications cable (e.g., 25-pair, 1200-pair, etc.); installation, termination, and testing of multi-strand optical fiber communications cable; installation, termination, and testing of category 6, 4-pair UTP communications station cable; Installation, termination, and testing of coax RG-11/RG-6 cabling, labeling of cables, WAO's and hardware; installation of equipment racks; installation of cable management hardware; and installation of termination frames, wall fields, and hardware.
  - 2.2.2 Qualified Technician/Installers shall perform communications cabling work on the Project as follows:
    - .1 Only qualified BICSI Technicians/Installers or those under direct on-site supervision of a BICSI Certified Technician shall install copper and fiber cable. Qualified Technician/Installers installing copper and fiber cable are those who:
      - .1 Are familiar with and routinely install communications cable in accordance with the methods specified in industry standard TIA/EIA 568-B and C, Commercial Building Communications Cabling Standard.
      - .2 Are familiar with and routinely install communications pathways in accordance with the methods specified in industry standard TIA/EIA 569-A, Commercial Building Standard for Communications Pathways and Spaces.
      - .3 Are familiar with the National Electrical Code adopted by the local Authority Having Jurisdiction and as applicable to cable installation to the extent that the methods and practices used to install communications cable comply with the Code.
      - .4 Install twisted-pair category 6 UTP communications cable routinely.
      - .5 Install multi-pair riser cable and optical fiber riser cable routinely.
      - .6 Install coax RG-11 and RG-6 cabling with compression connectors routinely.

- .7 Have a minimum of one year of experience installing, routing, support, and placement of category 6 communications cable and multi-pair riser cable and optical fiber riser cable.
- .8 Are accustomed to, familiar with, and routinely use tools and equipment for installation of multiple reels and large volumes of category 6 UTP, multi-pair copper cable, coaxial RG-11 and RG-6 cable, and SM/MM optical fiber riser cable.
- .9 Are accustomed to, familiar with, and routinely apply typical industry practices and methods for installation and support of multi-pair cable and category 6 twisted pair UTP communications cable and optical fiber riser cable.
- .10 Are a BICSI Certified Installer or are under the direct supervision of an onsite foreman who is a current BICSI Certified Technician and could provide copy of current updated certificate.
- .2 Only qualified BICSI Technicians/Installers or those trained specifically by the manufacturer of the cabling systems to be installed shall terminate and test copper cable. Qualified technicians terminating and testing copper cable are those who:
  - .1 Routinely install, terminate, and test the cable and connectivity products specified herein, or proposed on the bid.
  - .3 Are accustomed to, familiar with, and routinely use Level III and Level IV certification testers for twisted pair category 6 UTP communications cables and are knowledgeable to interpret and trouble shoot test results.
  - .4 Are a current BICSI Certified Technician, a Certified BICSI Installer or certified by the manufacturer of the cabling system to be installed and could provide copy of current certification certificate.
- .3 Only qualified Technicians shall splice copper cable. Qualified Technicians/Installers splicing copper cable are those who:
  - .1 Routinely terminate multi-pair copper cable.
  - .2 Are accustomed to, familiar with, and routinely use tools and equipment for splicing multi-pair cables.
  - .3 Are accustomed to, familiar with, and routinely use test equipment to verify correct pair splicing and are knowledgeable to interpret and trouble shoot test results.
  - .4 Are a current BICSI Certified Technician and could provide copy of current certification certificate.
- .4 Only qualified Certified Technicians shall splice, terminate, and test optical fiber cable. Qualified Technicians splicing, terminating, and testing optical fiber cable are those who:
  - .1 Routinely install and terminate multimode and single mode tight-buffered optical fiber cable.
  - .2 Routinely fusion splice optical fiber cable.
  - .3 Routinely install SC/ST/LC type connectors using 3M Hot Melt, Corning Quick Connect, and two parts epoxy methods.
  - .5 Are accustomed to, familiar with, and routinely use a power meter and light source for testing optical fiber and are knowledgeable to interpret and trouble shoot test results.
  - .6 Are accustomed to, familiar with, and routinely use OTDR for testing optical fiber and are knowledgeable to interpret and trouble shoot test results.
.7 Are a current Certified Technician and could provide copy of current certification certificate.

#### ARTICLE 3 - CONTRACTOR QUALIFICATION REQUIREMENTS

- 3.1 General
  - 3.1.1 Contractor qualification requirements are those required of the Contractor to perform the work on the Project.
  - 3.1.2 The qualification requirements are the minimum requirements.
  - 3.1.3 Qualification requires that all of the items in each category are satisfied and support documentation submitted to owner.
- 3.2 Project Administration
  - 3.2.1 The nature of the Project work necessitates a formally defined process of administration. Project administration includes project scheduling; crew scheduling; materials handling; tracking field changes; etc.
  - 3.2.2 Qualified Contractors are those who:
    - .1 Have experience managing projects equal to or larger than the project being bid.
    - .2 Are accustomed to, familiar with, and routinely use formal project administration practices and procedures.
    - .3 Have provided large project scheduling and are accustomed to and familiar with large project scheduling practices.
    - .4 Are accustomed to, familiar with, and routinely use project scheduling software.
- 3.3 Project Staffing
  - 3.3.1 The Project size and schedule requires teams of qualified Technicians/Installers performing work throughout the building. In general each team shall be dedicated to the Project until the work is complete in an effort to assure work continuity, familiarity with the Project and quality control. Teams include both qualified Technicians/Installers and supervisory personnel such as Project Managers. Those with PMP, TPM, or RCCD designation are desirable.
  - 3.3.2 Staffing requirements are driven by the building construction schedule.
  - 3.3.3 Qualified Contractors are those who:
    - .1 Have a minimum of 5 years' experience in this field of work.
      - .2 Can provide a dedicated team of qualified Technicians to complete the communications construction work within the construction time framed outlined by construction contractor and owner.
      - .3 Have a Registered Communications Distribution Designer (RCDD) or certified BICSI ITS Technician on staff to ensure project quality control and adherence to industry Communications standards as required by the project specifications.
- 3.4 Activation Experience (optional depending on scope description in Part 1 General. This section on activation does not apply if activation is included in Work by Owner.
  - 3.4.1 Activation work includes installation of cross-connect jumpers; verifying that the correct control, and monitoring signals appear at the outlet location, verifying that the correct designation number appears at the outlet location; plugging in telephones, facsimile machines etc., to the new cabling system, defining the activation strategy; applying an attention to detail to track cable records changes; planning and strategizing the Project cabling process such

that activation of the new communication circuits minimizes the quantity and duration of any required service outages.

- 3.4.2 Qualified Contractors are those who:
  - .1 Have performed the number of activations equal to or larger than the scope of the work for this Project.
  - .2 Can identify the methods they routinely apply to an activation process to ensure that the correct telephone number appears at the outlet.
  - .3 Can identify the methods they routinely apply to an activation process to ensure that all instruments are activated and plugged into the new outlet.

## SECTION 27 0513 – AREA OF RESCUE ASSISTANCE SYSTEM

#### PART 1 – GENERAL

#### 1.1 SUMMARY

A. Furnish, install, and wire all equipment associated with the installation of an Audio-Visual Rescue Assistance Signal System to comply with ADA requirements. This work shall include a main annunciator panel, remote call stations, power supply, auto dialer, outlet boxes, cables and wiring as shown on the drawings and as specified herein.

#### 1.2 SYSTEM OPERATIONS

- A. Furnish, install and place into operation a Rescue Assistance System for this building as indicated on the drawings and as specified herein.
- B. A common annunciator shall be provided at the main building entrance where shown on the drawings to indicate light and tone signals from multiple remote call stations.
  - 1. When the call station switch is activated, a red LED button illuminates and a one shot tone sounds.
  - 2. When the alarm signal is acknowledged, the remote call station is signaled with a flashing light and tone.
  - 3. Voice communication with the remote call shall be initiated from the annunciator.
  - 4. Access to a public telephone system shall be provided to contact off site Security Monitoring service, approved by Owner.

#### 1.3 INSTALLATION STANDARDS

- A. The system shall be installed in accordance with the following requirements:
  - 1. National Electrical Code (NEC)
  - 2. National Fire Protection Association (NFPA) Fire Alarm and Signaling Code
  - 3. Americans with Disabilities Act Accessibility Guidelines (ADAAG) requirements.
  - 4. International Building Code (IBC)
- B. The completed system shall be in compliance with state and local electrical codes.
- C. All wiring shall test free from grounds and shorts.
- 1.4 SUBMITTALS

- A. Data sheets on all equipment being provided as well recommended cable types. Internal control cabinet drawings showing internal block diagram connections shall be provided. Wiring diagrams showing typical field wiring connections as well as single line floor plan indicating equipment locations as well as cable routings and quantities.
- B. Product Data: Submit product data, including manufacturer's (Spec- Data) product sheet, for specified products.
- C. Shop Drawings: Submit shop drawings showing layout, profiles and product components, including anchorage and accessories. Include cabling diagrams, wiring diagrams, station installation details, and equipment cabinet details.
- D. Quality Assurance Submittals: Submit the following:
  - 1. Test Reports: Certified test reports showing compliance with specified performance characteristics.
  - 2. Manufacturer's Instructions: Manufacturer's installation instructions.
  - 3. Manufacturer's Field Reports: Manufacturer's field reports specified herein.
- E. Closeout Submittals: Submit the following:
  - Operation and Maintenance Data: Operation and maintenance data for installed products in accordance with Division 1 Closeout Submittals (Maintenance Data and Operation Data) Section. Include methods for maintaining installed products and precautions against cleaning materials and methods detrimental to finishes and performance. Include troubleshooting guide, wiring terminal identification and equipment parts list.
  - 2. Warranty: Warranty documents specified herein.

#### 1.5 WARRANTY

- A. Project Warranty: Refer to Conditions of the Contract for project warranty provisions.
- B. Manufacturer's Warranty: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under Contract Documents.
  - 1. Warranty Period: One (1) years commencing on the Date of Substantial Completion.
- C. All materials and installation shall be guaranteed to be free of defects in material and workmanship for one year after final acceptance of installation and tests.

#### PART 2 - PRODUCTS

#### 2.1 MANUFACTURER:

A. The Area of Rescue Assistance System is based on Rath

#### 2.2 ACCEPTABLE EQUIVALENT MANUFACTURERS

- A. Viking
- B. Cornell Communications Series 4200 Audio/Visual System.
- C. Vendor shall receive prior approval from Architect/Engineer and Building Owner prior to installation of any equivalent systems. It shall be the vendor's responsibility to show the A/E and Owner that the system being proposed will meet or exceed the standards included in this specification.

#### 2.3 SYSTEM EQUIPMENT

- A. This system shall consist of multiple remote call stations, which will share a common annunciator panel access to a public telephone system for external alarm notification.
- B. Wiring shall meet manufacturer's recommendations and local codes
  - 1. Approved for plenum use without conduit per NEC Article 800 by passing UL-910.

#### 2.4 ANNUNCIATOR

- A. RATH 2500-205FM flush mount to be installed between wall studs.
- B. Capacity of min. (4) zones. Annunciator panel shall be located at the Main Fire Department Entrance to the building, main vestibule or near the fire alarm annunciator panel.
- C. Verify location of annunciator panel with the Local Fire Marshal AHJ and the Architect/Owner.
- D. An alternate action switch with internal LED indicator shall be included for each zone.
  - 1. A yellow LED light on the zone switch shall illuminate and the alarm shall emit a repeating sound if the supervised wiring is faulted.
- E. An audible alarm shall be mounted on the annunciator panel, which will emit a minimum sound level of 90 db at 30 cm when a remote station calls.
  - 1. Depressing the zone switch will answer a zone and open the intercom line to the zone.
- F. The front panel shall have silk-screened zone designations and operating directions as well as zone designation strips.
- G. The power supply shall be a 120 volt with emergency battery backup.
- H. Telephone access kit will place a call to a designated location via a dedicated public telephone line to provide alarm notification.

#### 2.5 REMOTE CALL STATIONS

A. RATH 2100-958NSR flush mount

- B. Vandal resistant with one momentary switch with LED and loudspeaker.
- C. The station shall have hands free voice communication with the annunciator.
- D. The station shall have silk-screened operating instructions.
- E. The station shall be flush wall mounted on a 2-gang stainless steel plate with a 48" maximum mounting height for forward reach, and a 54" maximum for side reach.

#### 2.6 AREA OF RESCUE SIGNAGE

- A. The Area of Rescue locations shall include code required signs (ADAAG Parts 7050/7044/7049)
- B. IBC 1007.9 requires tactile signage complying with ICC A117.1 shall be located at each door leading to an Area of Rescue (Part 7044)
- C. Provide LED powered lighted room identification signage to lead people to the Area of Rescue Assistance. Signage shall contain battery back-up for 90 minutes as required by Code. Signage shall be capable of being single face or double face as needed.
- D. Signage shall state the words "AREA OF RESCUE ASSISTANCE".
- E. Tactile Signage at the call station must contain both raised letter and Braille.
- F. Mounting:
  - 1. The Area of Rescue Assistance illuminated signage shall mounted at or below 80" at the entrance to the Area of Rescue Assistance to confirm with character height and proportion.
  - 2. The Area of Rescue Assistance tactile signage shall mounted at or below 60" at the entrance to the Area of Rescue Assistance.
  - 3. The Area of Rescue Assistance instruction signage shall mounted next to the call box in the stairwell at or below 48" above finished floor.

#### PART 3 - EXECUTION

#### 3.1 MANUFACTURER'SINSTRUCTIONS

A. Compliance: Comply with manufacturer's product data, including product technical bulletins, product catalog installation instructions, and product carton instructions for installation.

#### 3.2 EXAMINATION

A. Site Verification of Conditions: Verify substrate conditions, which have been previously installed under other sections, are acceptable for product installation in accordance with manufacturer's instructions.

#### 3.3 INSTALLATION

- A. Cabling Requirements
  - 1. Wiring from the annunciator to the call station shall meet manufacturer and local code requirements.
  - 2. Verify cable types with the Rescue Assistance System Manufacturer.
  - 3. The optional telephone access kit requires a 120V AC outlet and dedicated external telephone line. Connect telephone line as required.
- B. Rescue Assistance Signal System Audio/Visual Installation
  - 1. Complete system shall be installed in strict accordance with manufacturer's recommendations.
  - 2. Wiring shall be installed in raceways throughout the building.
  - 3. Conduit, if required, shall be 1/2" minimum.

#### 3.4 FIELD/QUALITY CONDITIONS

- A. Site Tests (Post Installation Testing): Checkout final connections to the system shall be made by a factory technician authorized by the manufacturer of the products installed.
- B. Factory authorized technicians shall demonstrate operation of the complete system and each major component to the staff.
- C. System field wiring diagrams shall be provided to this subcontractor by the system prior to installation.
- D. Inspection: Perform a complete functional test of the system upon completion of the installation and instruct the staff in the operation and maintenance of the system.

#### 3.5 CLEANING

A. Cleaning: Repair or replace damaged installed products. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance. Remove construction debris from project site and legally dispose of debris.

#### END OF SECTION

#### SECTION 27 0526 – GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

## PART 1 - GENERAL

- 1.01 SECTION INCLUDES
  - A. Grounding and Bonding Conductors
  - B. Splices and Termination Components
  - C. Grounding Busbars
  - D. Grounding Connections
  - E. Equipment Rack and Cabinet Grounding Busbars
  - F. Grounding Terminal Blocks
  - G. Splice Case Grounding Accessories
  - H. Labels

# 1.02 RELATED WORK

- A. Section 26 05 00 Common Work Results for Electrical
- B. Section 26 05 26 Grounding and Bonding for Electrical Systems
- C. Section 26 05 53 Identification for Electrical Systems
- D. Section 27 05 00 Common Work Results for Communications Systems
- E. Applicable Publications
  - 1. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
  - 2. American Society for Testing and Materials (ASTM):
    - a. B1-2001 Standard Specification for Hard-Drawn Copper Wire
    - b. B8-2004 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
  - 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
    - a. 81-1983 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
  - 4. National Fire Protection Association (NFPA):
    - a. 70-2005 National Electrical Code (NEC)
  - 5. Telecommunications Industry Association, (TIA)
    - a. J-STD-607-A-2002 Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
  - 6. Underwriters Laboratories, Inc. (UL):
    - a. 83-2003 Thermoplastic-Insulated Wires and Cables
    - b. 467-2004 Grounding and Bonding Equipment
- 1.03 SUBMITTALS
  - A. Submit shop drawings for equipment under this section per requirements listed herein, as well as per section 01 33 00.
  - B. Submittals shall be grouped with related systems
  - C. Submit catalog sheets or photocopies. Do not submit hard copies of web pages. Web pages change frequently and will be rejected.
  - D. Circle noted item with black pen or use arrows that can be copied.

#### PROJECT NO. 18-168.00 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS HARBORCHASE OF FARMINGTON HILLS, MICHIGAN 27 0526 - 2 HRA 10/24/2019 PERMIT SET

- E. At end of project submit record documents, as-builts, certificates, warranties and other operational manual documents to assist owner to maintain all systems.
- F. Work shall not proceed without Engineer's approval of submitted items. Materials that are installed without Engineer approval risk forced removal by contractor at Engineer request.

# G. Shop Drawings:

- 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
- 2. Include the location of system grounding to main electrical service ground.

# 1.04 PERFORMANCE TESTING

- A. Test Report: Provide to Engineer a certified test report of ground resistance with explanation of procedure. At a minimum test shall include links from TGB to TMGB and TMGB to main electrical ground bus.
- B. Certifications: Two weeks prior to final inspection, submit four copies of the following to the Engineer:
  - 1. Certification that the materials and installation is in accordance with the drawings and specifications.
  - 2. Certification that the entire installation has been properly installed and tested.

# 1.05 WORK INCLUDES

- A. Complete communications grounding and bonding system dedicated to the use of communications systems, but connected to the main electrical service ground of the building.
- B. Grounding risers, backbones, bus bars, equipment bonds, 2-hole connectors, paint-piercing washers, labels, and all supporting equipment to provide a complete installation as indicated on the project documents.
- C. This section specifies general grounding and bonding requirements of telecommunications installations.
- D. "Grounding electrode system" refers to all electrodes required by NEC as well as supplementary, telecommunications system grounding electrodes.
- E. The terms "connect" and "bond" are used interchangeably in this specification and have the same meaning.
- F. Bonding to ground of all metallic components of the communications system indicated on the project documents and including, but not limited to: data racks, overhead runway, equipment panels and boxes, chassis, cable shields, TGB, TMGB, main electrical service ground.

#### 1.06 DESCRIPTION

- A. System includes two major components:
  - 1. Riser system consisting of copper bus bars in TRs and MTR, large wire size riser conductors.
  - 2. Local system within TRs consisting of smaller conductors to each system component.

#### 1.07 DEFINITIONS

- A. TGB Telecommunications Ground (Bus) Bar (also called SBB secondary busbar)
- B. TMGB Telecommunications Main Ground (Bus) Bar (also called PBB primary busbar)
- C. TBB Telecommunications Bonding Backbone Grounding Riser Conductor cable of large wire size connecting TGB to TMGB. Also used below raised floor tiles to connect floor pedestals and data cabinets.
- D. TR Telecommunications Room.
- E. MTR Main Telecommunications Room

# PART 2 – PRODUCTS

# 2.01 GROUNDING AND BONDING CONDUCTORS

- A. Equipment grounding conductors shall be insulated stranded copper, except that sizes 6 mm<sup>2</sup> (10 AWG) and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors. Where permitted, conductors larger than #4 may remain bare.
- B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes 6 mm<sup>2</sup> (10 AWG) and smaller shall be ASTM B1 solid bare copper wire.
- C. TBB (Grounding Riser Conductor): TBB shall be in accordance with J STD-607A. Use a minimum 50mm<sup>2</sup> (1/0 AWG) stranded copper grounding conductor unless indicated otherwise.

# 2.02 SPLICES AND TERMINATION COMPONENTS

- A. Components shall meet or exceed requirements of nationally recognized testing laboratory and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).
- B. Use only HTAP crimp style splice connections when bonding one cable to another (same sized cables or different sized cables).
- C. 14 ton electric, battery powered or manual crimping tools with appropriately sized dies for each splice connection.
- D. Obtain special permission from Engineer before using exothermic welding technique to join conductors.

## 2.03 GROUNDING BUSBARS

- A. Provide solid copper busbar, pre-drilled for (2) two-hole lug connections with a minimum thickness of 6 mm (1/4 inch) for wall and backboard mounting using standard insulators sized as follows:
  - 1. TGB: 12 inches x 4 inch
  - 2. TMGB: 20 inches x 4 inch
  - 3. Double lug hole pattern only
  - 4. Tinned to resist corrosion

# 2.04 GROUNDING CONNECTIONS

#### A. Above Grade:

- 1. Bonding Jumpers: compression type connectors, using zinc-plated fasteners and external tooth lockwashers. All connections shall be Two-hole type.
- 2. Ground Busbars: Two-hole compression type lugs using tin-plated copper or copper alloy bolts and nuts.
- 3. Rack and Cabinet Ground Bars: two-hole compression-type lugs using zinc-plated or copper alloy fasteners.
- 4. Antioxidant compound shall be used for all bonding connections.
- B. Cable Shields: Make ground connections to multipair communications cables with metallic shields using shield bonding connectors with screw stud connection.

# 2.05 EQUIPMENT RACK AND CABINET GROUNDING BUSBARS

- A. Provide solid copper ground bars designed for mounting on the19" framework of open or cabinetenclosed equipment racks with minimum dimensions of 4 mm thick by 19 mm wide (3/8 inch x <sup>3</sup>/<sub>4</sub> inch).
- 2.06 GROUNDING TERMINAL BLOCKS

- A. At any equipment mounting location (e.g. backboards inside of hinged cover enclosures) where racktype ground bars cannot be mounted, provide screw lug-type terminal blocks.
- 2.07 SPLICE CASE GROUNDING ACCESSORIES
  - A. Splice case grounding and bonding accessories shall be supplied by the splice case manufacturer when available. Otherwise, use 6 AWG insulated ground wire with shield bonding connectors.
- 2.08 LABELS
  - A. Each conductor to be labeled at the TGB or TMGB indicating date of installation and destination or system to which the conductor is attached
  - B. Similar to Panduit product LTYK Bonding Conductor Label Kit
  - C. Machine produced black lettering on white or yellow background.
  - D. Tie-wrapped or attached to conductor in a secure manner.

# PART 3 – EXECUTION

# 3.01 GROUNDING AND BONDING CONDUCTORS

- A. General
  - 1. Ground in accordance with the NEC and J-STD-607-A, as shown on drawings, and as hereinafter specified.
  - 2. Equipment Grounding: Metallic structures (including building steel), enclosures, raceways, junction boxes, outlet boxes, cabinets, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.
  - Install all conductors as straight as possible, using only long sweep bends when a change of direction is required. Sharp 90s will be rejected. DO NOT install conductors with sharp changes in direction, kinks, bends, or loops. Minimize length of cable whenever possible by taking the shortest route available.
  - 4. Conductors, bends and splices shall be installed such that they "flow" (usually downward) toward the TGB or TMGB. See details.
  - Telecommunications Bonding Backbone (TBB) shall be one continuous conductor without breaks, connections or splices from the highest floor to the lowest. TBB may connect directly to TMGB or continue on to the main electrical service entrance.
  - 6. Main Bonding Jumper: Bond the TMGB to the ground bus in the main electrical service equipment for the building.
  - Metallic Piping, Building Steel, and Supplemental Electrode(s): Confirm with Electrical Contractor that he has provided a grounding electrode conductor sized per NEC between the service equipment ground bus and all metallic water and gas pipe systems, building steel, and supplemental or made electrodes.
- B. Telecommunications Systems
  - 1. Bond telecommunications system grounding equipment to the electrical grounding electrode system.
  - 2. Telecommunications Conduit Systems:
    - Ground all metallic conduit systems and cable trays for telecommunications.
  - 3. Boxes, Cabinets, and Enclosures:
    - Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures used for telecommunications.

- 4. Furnish and install all wire and hardware required to properly ground, bond and connect communications raceway, cable tray, metallic cable shields, and equipment to a ground source.
- 5. Ground bonding jumpers shall be continuous with no splices. Use the shortest length of bonding jumper possible.
- 6. Provide ground paths that are permanent and continuous with a resistance of 3 ohm or less from raceway, cable tray, and equipment connections to the building grounding electrode or main electrical service entrance ground. The resistance across individual bonding connections shall be 10 milli ohms or less.
- C. Bonding Jumpers:
  - 1. Use insulated ground wire of the size and type shown on the Drawings or use a minimum of 16 mm<sup>2</sup> (6 AWG) insulated copper wire.
- D. Coordination with Electrical Contractor
  - 1. Contractor to provide all grounding components indicated in project documents.

2. General Contractor may selectively partition division of labor between Electrical Contractor and Low Voltage Contractor. Typically the Electrical Contractor will provide all equipment outside of the Telecom Rooms, including the TBB and bonding to the main electrical service ground. The Low Voltage Contractor will typically provide all equipment within the telecom rooms. Without a GC to make this determination, contractor shall provide all equipment, wire, connections and labor as indicated on project documents.

# 3.02 SPLICES AND TERMINATION COMPONENTS

- A. Use only HTAP crimp style splice connections when bonding one cable to another (same sized cables or different sized cables).
- B. 14 ton electric, battery powered or manual crimping tools with appropriately sized dies for each splice connection.
- C. Use crimp connections to 2-hole, double lug type connectors.

#### 3.03 GROUNDING BUSBARS

- A. Provide grounding busbars in every TR and MTR/MDF and Audio Visual equipment room. Provide grounding busbars in any other room dedicated to telecommunications equipment. If an entire room is not designated, but only a cabinet, provide busbar within or near cabinet.
  - 1. In TRs provide TGB sized at 12 inches x 4 inch mounted on insulated bushings.
  - 2. In MTR provide TMGB: 20 inches x 4 inch
  - 3. Double lug hole pattern only
  - 4. Tinned to resist corrosion
  - 5. In cabinets or on racks provide 19" wide busbar for local equipment grounding.
  - 6. Connect all metallic systems within a TR or MTR to the nearest TGB.
  - 7. Connect all TGBs to the TMGB by means of the TBB. See details.
  - 8. Connect the TMGB to the main electrical service entrance ground for the building.
  - 9. Connect TGBs to nearby building steel and/or the local electrical panel ground from which power to the TR is derived per J-STD-607-A if so indicated on details. Some jurisdictions do not desire this configuration but prefer only one connection at the main electrical service ground.
  - 10. If during a renovation access to the main electrical service ground is not possible or cost prohibitive, connections noted in item 9 above must be made. Obtain prior Engineer approval if access to the main electrical service ground is deemed impractical.
  - 11. Provide additional busbars or larger busbars as required to provide termination point for all bonding locations.
  - 12. Install busbars at 18" above finished floor unless noted otherwise on project documents.

13. Install busbars at easily accessible, visible locations near data racks or entrance cables unless noted otherwise on project documents.

# 3.04 GROUNDING CONNECTIONS

- A. General
  - 1. Provide lugs in each box and enclosure for equipment grounding conductor termination.
  - 2. Corrosion Inhibitors: When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.
  - Above-Grade Grounding Connections: When making bolted or screwed connections to attach bonding jumpers, remove paint to expose the entire contact surface by grinding where necessary; thoroughly clean all connector, plate and other contact surfaces; and apply an appropriate corrosion inhibitor to all surfaces before joining.
  - 4. Assemble bonding jumpers using insulated ground wire terminated with compression connectors.
  - 5. Use compression connectors of proper size for conductors specified. Use connector manufacturer's compression tool.
- B. Bonding Jumper Fasteners:
  - Conduit: Fasten bonding jumpers using screw lugs on grounding bushings or conduit strut clamps, or the clamp pads on push-type conduit fasteners. When screw lug connection to a conduit strut clamp is not possible, fasten the plain end of a bonding jumper wire by slipping the plain end under the conduit strut clamp pad; tighten the clamp screw firmly. Where appropriate, use zinc-plated external tooth lockwashers.
  - 2. Wireway and Cable Tray: Fasten bonding jumpers using zinc-plated bolts, external tooth lockwashers, and nuts. Install protective cover, e.g., zinc-plated acorn nuts on any bolts extending into wireway or cable tray to prevent cable damage.
  - 3. Ground Plates and Busbars: Fasten bonding jumpers using two-hole compression lugs. Use tinplated copper or copper alloy bolts, external tooth lockwashers, and nuts.
  - 4. Unistrut and Raised Floor Stringers: Fasten bonding jumpers using zinc-plated, self-drill screws and external tooth lockwashers.
  - 5. Always grind away paint and use antioxidant compound before making connections.

#### 3.05 EQUIPMENT RACK AND CABINET GROUNDING BUSBARS

- A. General
  - 1. Provide one grounding busbar at the bottom of every rack or cabinet.
  - 2. Bond to TGB with #6 copper conductor.
  - 3. Do not daisy-chain between racks. Each rack should have its own conductor to the TGB. Or one conductor may be run from the farthest rack and others may splice to it using HTAP connectors.

#### 3.06 GROUNDING TERMINAL BLOCKS

A. Provide as required in riser shafts and other areas not served by a TGB or standard data rack.

#### 3.07 SPLICE CASE GROUNDING ACCESSORIES

- A. Provide grounding bars, clamps, or other accessories as required in and near copper cable splice cases to maintain cable shield ground continuity from one side of splice to the other.
- B. Provide same for fiber optic splices if metallic members are included in cable assembly.
- C. Provide grounding bars, clamps or other accessories as required within handholes and manholes if provided by this project. This may include provision additional ground rods if not near a facility with metallic conduit or access to a TGB.

## 3.08 LABELS

- A. Label all bonding conductors at TGB and TMGB with approved label.
- B. In addition to any pre-printed information on label, add the following:
  - 1. Date of installation
  - 2. Far end termination location or system
  - 3. Example: "To Cable Tray", "To Runway", "To Data Racks", "To Main Electrical Service Panel".

#### 3.09 COMMUNICATIONS CABLE GROUNDING

- A. Bond all metallic cable sheaths in multipair communications cables together at each splicing and/or terminating location to provide 100 percent metallic sheath continuity throughout the communications distribution system.
- B. At terminal points, install a cable shield bonding connector; provide a screw stud connection for ground wire. Use a bonding jumper to connect the cable shield connector to an appropriate ground source like the rack or cabinet ground bar.
- C. Bond all metallic cable shields together within splice closures using cable shield bonding connectors or the splice case grounding and bonding accessories provided by the splice case manufacturer. When an external ground connection is provided as part of splice closure, connect to an approved ground source and all other metallic components and equipment at that location.

# 3.10 COMMUNICATIONS CABLE TRAY SYSTEMS

- A. Bond the metallic structures of one cable tray in each tray run following the same path to provide 100 percent electrical continuity throughout the cable tray systems as follows:
- B. Splice plates provided by the cable tray manufacturer can be used for providing a ground bonding connection between cable tray sections when the resistance across a bolted connection is 10 milliohms or less. The Subcontractor shall verify this loss by testing across one slice plate connection in the presence of the Contractor.
- C. Install a 16 mm<sup>2</sup> (6 AWG) bonding jumper across each cable tray splice or junction where splice plates cannot be used.
- D. When cable tray terminations to cable rack, install 16 mm<sup>2</sup> (6 AWG) bonding jumper between cable tray and cable rank pan.

#### 3.11 COMMUNICATIONS RACEWAY GROUNDING

- A. Conduit: Use insulated 16 mm<sup>2</sup> (6 AWG) bonding jumpers to ground metallic conduit at each end and to bond at all intermediate metallic enclosures.
- B. Wireway: use insulated 16 mm<sup>2</sup> (6 AWG) bonding jumpers to ground or bond metallic wireway at each end at all intermediate metallic enclosures and across all section junctions.
- C. Cable Tray Systems: Use insulated 16 mm<sup>2</sup> (6 AWG) bonding jumpers to ground cable tray to columnmounted building ground plates (pads) at each end and approximately every 16 meters (50 feet).

#### 3.12 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 3 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to the Government. Final tests shall assure that this requirement is met.
- B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate

systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

END OF SECTION

# SECTION 27 0553 – IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

## PART 1 – GENERAL

#### 1.01 SCOPE OF WORK

- A. Furnish, and install all materials and equipment and provide all labels required as shown on the Drawings, Schedules and as specified.
- B. It is the intent of the Specifications, Drawings and Schedules that all labels will be machine based labels which are legible and provided in locations which are readily visible.
- C. Only those items affected by the installation of the Project shall be labeled unless otherwise indicated.
- D. Labeling includes all riser cables, horizontal cables, faceplates, patch panels, cabinets, wall fields, grounding/bonding conductors and bus bars.

#### 1.02 SECTION INCLUDES

A. Termination Hardware and Cable Labels

# 1.03 RELATED WORK

- A. Section 27 05 00 Common Work Results for Communications Systems
- B. All references including Division 26 apply
- C. The work in this section is subject to requirements of the Contract Documents including General Conditions, Supplementary Conditions and sections under Division 1, General Requirements.

#### 1.04 SUBMITTALS

- A. Submit product data as required herein under provisions of Section 27 05 00 Common Work Results for Communications Systems.
- B. Submit product data for the following:
  - 1. Manufacturer and model of labeling device.
  - 2. Proposed method of jack labeling, including nomenclature and syntax.
- C. Submit shop drawings for equipment under each section per requirements listed in that section, as well as per Division 1.
- D. Submittals shall be grouped with related systems
- E. Submit catalog sheets or photocopies. Do not submit hard copies of web pages. Web pages change frequently and will be rejected.
- F. Circle noted item with black pen or use arrows that can be copied.
- G. At end of project submit record documents, as-builts, certificates, warranties and other operational manual documents to assist owner to maintain all systems.
- H. Work shall not proceed without Engineer's approval of submitted items. Materials that are installed without Engineer approval risk forced removal by contractor at Engineer request.
- Shop Drawings shall contain sufficient information, clearly presented, to determine compliance with drawings, specifications and design intent. Include additional information and products that may be required to provide a complete, functioning system even if those items are not specifically listed in the project documents.

#### 1.05 WORK INCLUDES

- A. A complete, integrated, organized, intuitive labeling system for all communications cables and equipment.
- B. Labels using black ink on white paper, printed plastic or engraved tags.

# PERMIT SET

- C. Labeling for riser cables, horizontal station cables, faceplates, patch panels, cabinets, wall fields, grounding/bonding conductors and bus bars.
- D. Accurate as-built documentation in AutoCAD format that matches one-to-one the labels provided in the field.

# 1.06 STANDARDS AND CODES

- A. Work shall be installed in accordance with national and state laws, ordinances, and regulations. All applicable OSHA regulations shall be complied with.
- B. Unless otherwise noted, all labels at distribution frames shall follow the color coding scheme identified by the owner.

#### 1.07 DIMENSIONS AND DEFINITE LOCATIONS

- A. Unless otherwise indicated, the exact location of labels shall be established in the field in accordance with instructions from the Owner. Consideration shall be given to construction features, label placement as affected by Work by other Trades, and label placement to provide maximum benefit and minimum obstruction of physical equipment and hardware features.
- B. The Owner shall provide information regarding the labels for the optical fiber enclosures. Do not use the manufacturer's supplies placards.

#### 1.08 DRAWINGS AND SPECIFICATIONS

- A. The Contractor shall keep a detailed up-to-date record of the label information and placement of all labels installed as specified herein.
- B. The Contractor shall fill-in the label information on the forms or data documents provided by the Owner. The information requested is typically that which can only be provided after installation.

## 1.09 SUBSTITUTIONS

A. No substitutions shall be allowed unless specified.

#### 1.10 CLEANING

- A. The Contractor shall clean all surfaces prior to the attachment of labels. Follow the manufacturer's recommendations for cleaning.
- B. The Contractor shall follow the manufacturer's recommendations for affixing labels.

# PART 2 – PRODUCTS

#### 2.01 TERMINATION HARDWARE AND CABLE LABELS

- A. Acceptable Manufacturers of Labeling Machine:
  - 1. Panduit
  - 2. Brady
  - 3. Silver Fox
  - 4. System manufactured for or by the proposed structure cabling system
- B. Acceptable Methods:
  - 1. Black letters on white paper
  - 2. Machine produced, not hand written
  - 3. Arial or block font
  - 4. Black letters printed on light colored plastic
  - 5. Labels as part of a manufacturer's system or product
  - 6. Engraved plastic or metallic tags
  - 7. Black letters on reflective yellow, sticky-backed products sometimes used for telco applications to label large cables, splices, wall fields and pedestals.

8. Permanent

## PART 3 – EXECUTION

## 3.01 SPACES

- A. Item: Telecommunications Room (TR):
  - 1. Provide label on plywood near system patch panels indicating room number.
  - 2. Large black letters on reflective yellow, sticky-backed label.

# 3.02 CABLING

- A. Multi-Pair Copper Backbone Cabling
  - 1. Item: Telephone Backbone Riser Cabling
    - a. Label Location: On the cable at both ends, near the hardware on which the cable is terminated. Also place label on cable within every accessible riser shaft space on every floor.
    - b. Label Information: See copper cable and equipment specification
    - c. Method: Printed label, permanently attached.
    - d. Format: All capital letters. Font should be as large as possible to fill the label space with the information. The font should be Helvetica or equal and bold. Two line format with the cable number on the top line and the cable count below. Center the text and use a dash as delimiter.
    - e. Example: See copper cable and equipment specification
- B. Optical Fiber Backbone Cabling
  - 1. Item: Optical Fiber Backbone Cabling
    - a. Label Location: On the jacket or sheath of the cable at both ends (before the fan-out or breakout point). Place the label near the cable entrance into the termination hardware and exterior to the termination hardware. Also place label on cable within every accessible riser shaft space on every floor.
    - b. Label Information: See fiber cable and equipment specification
    - c. Method: Machine printed Brady Labels, permanently attached.
    - d. Format: All capital letters. Font should be as large as possible to fill the label space with the information. The font should be Helvetica or equal and bold. Two line format with the cable number on the top line and the cable count below. Center the text and use a dash as delimiter.
    - e. Example: See fiber cable and equipment specification

#### 3.03 TERMINATION HARDWARE

A. See design/construction documents for example of wall field layout and labeling.

- 1. Copper Termination Hardware
- B. Item: SIO faceplate
  - 1. Label Location: On the top of the faceplate in the outlet location window and behind the clear plastic window.
  - 2. Label Information: See copper cable specification
  - Method: Manufacturer's white paper inserts. Print the information on an adhesive label and affix the label to the paper insert. Labels shall not be affixed to the clear plastic window. Install icon representing service at that jack position as defined by the cable records.
    - a. Machine printed Brady Labels.
    - b. Brady label part number:
  - 4. Format: Font should be sized to fill the area of the strip. The font should be Helvetica or equal and bold. Use one line format.
  - 5. Example: See copper cable specification

- C. Fiber Termination Hardware
  - 1. Item: Fiber Patch Panel Enclosures
  - 2. Label Location: On face of patch panel
  - 3. Label Information: See Fiber Optic Cable specification
  - 4. Method: Machine printed Brady Labels.
  - 5. Format: The font should be Helvetica or equal and bold.
  - 6. Example: See Fiber Optic Cable specification
- D. Fiber Terminations
  - 1. Item: Optical fiber terminations
    - a. The connector type and layout within each enclosure may vary. See Owner for specific connectors needed for this project and refer to the construction documents.
    - b. Label Location: On front of patch panel above fiber port
    - c. Label Information: See Fiber Optic Cable specification
    - d. Method: Machine printed Brady Labels.
    - e. Format: See Fiber Optic Cable specification

# 3.04 EQUIPMENT AND EQUIPMENT RACKS

- A. Item: Equipment Racks
  - 1. The equipment racks are typically 19" free-standing or wall-mounted relay racks, floor mounted cabinets or wall mounted cabinets.
  - 2. Label Location: On front surface above door
  - 3. Method: Machine printed Brady Labels
  - 4. Format: Large font, black letters on white background, indicate cabinet number
  - 5. Example: CABINET #1, CABINET #2, etc.
- 3.05 GROUNDING AND BONDING
  - A. See grounding details on drawings for labeling procedures.

END OF SECTION

# SECTION 27 0560 – FIRESTOPPING FOR COMMUNICATIONS

# PART 1 - GENERAL

- 1.01 SECTION INCLUDES
  - A. Firestopping of through Penetrations in Fire Rated Assemblies
  - B. Smoke Seals
  - C. Construction Enclosing Compartmentalized Areas

# 1.02 RELATED WORK

- A. Section 03 30 00 Cast-In-Place Concrete
- A. Section 04 20 00 Unit Masonry
- B. Section 07 84 00 Firestopping
- C. Section 09 21 16 Gypsum Board Assemblies
- D. Section 26 00 00 Electrical
- E. Section 27 05 00 Common Work Results for Communications Systems

# 1.03 SUBMITTALS

- A. Submit under provisions of Section 01 33 00.
- B. Product Data: Provide manufacturer's standard catalog data for specified products demonstrating compliance with referenced standards and listing numbers of systems in which each product is to be used.
- C. Shop Drawings: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings.
- D. Certificates: Product certificates signed by firestop system manufacturer certifying material compliance with applicable code and specified performance characteristics.
- E. Installation Instructions: Submit manufacturer's printed installation instructions.

#### 1.04 REFERENCE STANDARDS

- A. ASTM E 84 Surface Burning Characteristics of Building Materials
- B. ASTM E 119 Fire Tests of Building Construction and Materials
- C. ASTM E 814 Fire Tests of Through Penetration Firestops
- D. ANSI/UL263 Fire Tests of Building Construction and Materials
- E. ANSI/UL723 Surface Burning Characteristics of Building Materials
- F. ANSI/UL1479 Fire Tests of Through Penetration Firestops
- G. Underwriters Laboratories Inc. (UL) Fire Resistance Directory
- H. National Fire Protection Association (NFPA) NFPA 101: Life Safety Code.
- I. National Fire Protection Association (NFPA) NFPA 70: National Electrical Code.

#### 1.05 QUALITY ASSURANCE

- A. Products/Systems: Provide firestopping systems that comply with the following requirements:
  - 1. Firestopping tests are performed by a qualified, testing and inspection agency. A qualified testing and inspection agency is UL, or another agency performing testing and follow-up inspection services for firestop system acceptable to authorities having jurisdiction.
  - 2. Firestopping products bear the classification marking of qualified testing and inspection agency.

3. Installer Qualifications: Experience in performing work of this section who is qualified by the firestopping manufacturer as having been provided the necessary training to install firestop products in accordance with specified requirements.

## 1.06 DELIVERY, STORAGE AND HANDLING

- A. Delivery:
  - 1. Manufacturer's original, unopened, undamaged containers, identification labels intact identifying product and manufacturer, date of manufacture; lot number; shelf life, if applicable; qualified testing and inspection agency's classification marking; and mixing instruction for multi-component products.
  - 2. Handle and store products according to manufacturer's recommendations published in technical materials. Leave products wrapped or otherwise protected and under clean and dry storage conditions until required for installation.
- B. Storage and Protection:
  - 1. Store materials protected from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

# 1.07 PERFORMANCE REQUIREMENTS

- A. Fire rated pathway devices shall be the preferred product and shall be installed in all locations where frequent cable moves, add-ons and changes will occur.
- B. Where non- mechanical products are utilized, provide products that upon curing do no re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during or after construction.
- C. Where it is not practical to use a mechanical device, openings within floors and walls designed to accommodate telecommunications and data cabling shall be provided with re-enterable products that do not cure or dry.
- D. Openings for cable trays shall be sealed using re-enterable firestopping pillows.
- E. Only UL listed, approved or certified systems shall be installed.

#### 1.08 PROJECT CONDITIONS

- A. Do not install firestopping products when ambient or substrate temperatures are outside limitations recommended by manufacturer.
- B. Do not install firestopping products when substrates are wet due to rain, frost, condensation, or other causes.
- C. Maintain minimum temperature before, during, and for a minimum 3 days after installation of materials.
- D. Do not use materials that contain flammable solvents.
- E. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.
- F. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate throughpenetration firestop systems.
- G. Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

# PART 2 - PRODUCTS

# 2.01 MANUFACTURERS

- A. Acceptable Manufacturer: Specified Technologies Inc., 200 Evans Way, Somerville, NJ 08876. Tel: (800) 992-1180, Fax: (908) 526-9623, Email: <u>specseal@stifirestop.com</u>, Website: <u>www.stifirestop.com</u>.
- B. Substitutions: HILTI

# PERMIT SET

- C. Single Source: Obtain firestop systems for each type of penetration and construction condition indicated only from a single manufacturer.
- D. TENMAT <u>www.Tenmatusa.com</u> to maintain fire rating assemblies for speakers and other communications equipment.

# 2.02 MATERIALS

- A. General: Use only firestopping products that have been tested for specific fire resistance rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire rating involved for each separate instance.
- B. Firestop Sealants: STI SpecSeal® Brand single component latex formulations that upon cure do not reemulsify during exposure to moisture, the following products are acceptable:
  - 1. Specified Technologies Inc. (STI) SpecSeal® Series SSS Sealant
  - 2. Specified Technologies Inc. (STI) SpecSeal® Series LCI Sealant
- C. Firestop Putty: STI SpecSeal® Brand intumescent, non-hardening, water resistant putties containing no solvents, inorganic fibers or silicone compounds, the following products are acceptable:
  - 1. Specified Technologies Inc. (STI) SpecSeal® Series SSP Putty
- D. Firestop Pillows: STI SpecSeal® Brand re-enterable, non-curing, mineral fiber core encapsulated on six sides with intumescent coating contained in a flame retardant poly bag, the following products are acceptable:
  - 1. Specified Technologies Inc. (STI) SpecSeal® Series SSB Pillows
- E. Fire Rated Cable Pathways: STI EZ-PATH<sup>™</sup> Brand device modules comprised of steel raceway with intumescent foam pads allowing 0 to 100 percent cable fill, the following products are acceptable:
  - 1. Specified Technologies Inc. (STI) EZ-PATH™ Fire Rated Pathway
  - 2. Use EZ path system for all 4" sleeve openings from Telecom Rooms to hallways.

# PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Before beginning installation, verify that substrate conditions previously installed under other sections are acceptable for installation of firestopping in accordance with manufacturer's installation instructions and technical information.
- B. Surfaces shall be free of dirt, grease, oil, scale, laitance, rust, release agents, water repellants, and any other substances that may inhibit optimum adhesion.
- C. Provide masking and temporary covering to protect adjacent surfaces.
- D. Do not proceed until unsatisfactory conditions have been corrected.

# 3.02 INSTALLATION

- A. General: Install through-penetration firestop systems in accordance with Performance Criteria and in accordance with the conditions of testing and classification as specified in the published design.
- B. Manufacturer's Instructions: Comply with manufacturer's instructions for installation of firestopping products.

#### 3.03 FIELD QUALITY CONTROL

- A. Inspections: Owner shall engage qualified independent inspection agency to inspect throughpenetration firestop systems.
- B. Keep areas of work accessible until inspection by authorities having jurisdiction.
- C. Where deficiencies are found, repair firestopping products so they comply with requirements.

#### 3.04 ADJUSTING AND CLEANING

- A. Remove equipment, materials, and debris, leaving area in undamaged, clean condition.
- B. Clean all surfaces adjacent to sealed openings to be free of excess firestopping materials and soiling as work progresses.

END OF SECTION

# SECTION 27 1100 – COMMUNICATION ROOM PROVISIONING

#### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Free Standing 2-Post Racks
- B. Wall-mount Equipment Cabinets
- C. Cable Management
- D. Flexible Nonmetallic Innerduct
- E. Cable Runway
- F. Miscellaneous Equipment

#### 1.02 RELATED WORK

- A. Section 27 05 00 Common Work Results for Communications Systems
- B. All references including Division 26 apply.
- C. The Work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

#### 1.03 SUBMITTALS

- A. Submit product data indicating construction, materials, ratings and all other parameters.
- B. Submittals shall be grouped to include complete documentation of related systems, products and accessories in a single submittal. If provided electronically in PDF format, one Specification Section should equal one file or file name. Do not scan multiple Specification Sections into one file.
- C. Where applicable, dimensions shall be marked in units to match those specified.
- D. Submittals shall be original catalog sheets or photocopies thereof. Facsimile (fax) sheets, web pages and supplier/distributor information will not be accepted.
- E. Where more than one product appears on a page, circle or clearly mark products submitted with black ink (not high-lighted).
- F. Submit manufacturer's installation instructions

#### 1.04 REFERENCE STANDARDS

- A. BICSI TDMM Telecommunications Distribution Methods Manual.
- B. TIA/EIA 568-B.1-B.3 Commercial Building Telecommunications Cabling Standard.
- C. TIA/EIA 569-B Commercial Building Standard for Telecommunications Pathways and Spaces.
- D. TIA/EIA 606 The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
- E. TIA/EIA 607 Commercial Building Grounding and Bonding Requirements for Telecommunications.
- F. UL 910 Test for Flame Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables used in Spaces Transporting Environmental Air.
- G. UL 1660 Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
- H. NFPA 70 National Electric Code 2011.
- 1.05 DESCRIPTION

PERMIT SET

- A. Provide complete telecommunication room (TR) fit out including all racks, cabinets, overhead runway, innerduct, busbars, grounding and bonding, wall mounted equipment and cable management.
- B. Coordinate with GC for provision of plywood backboard prior to submitting bids. It is preferable that the CG (carpenters) provide the plywood on the wall surfaces due to their skills and access to materials. If the GC does not provide the plywood, this DIV 27 contractor shall provide it.
- C. See Part 2 below for plywood requirements.
- PART 2 PRODUCTS
- 2.01 FREE STANDING 2-POST RACK
  - A. Manufacturers: Hoffman
  - B. General:
    - 1. Part no. EDR19FM45U
    - 2. Equipment racks shall be:
      - a. Constructed of painted (black) or anodized aluminum.
      - b. Supplied with ground bar (19" wide by 1" high) and #6 AWG ground lugs.
      - c. Supplied with minimum of 12 releasable cable support ties (e.g. "hook and loop").
      - d. Supplied with spare screws (minimum of 50)
    - 3. Channel uprights shall be spaced to accommodate industry standard 19" mounting.
      - a. 2-Post floor mount racks
      - b. Standard 2-post rack with 19" mounting space, painted black, bolted to floor at bottom and to wall at top.
      - c. 7 ft. (84") tall rack, 45 rack units (RU). EIA/TIA tapped holes both sides, alternating pattern
      - d. High strength extruded aluminum
      - e. 1000 lb. capacity
- 2.02 WALL-MOUNT EQUIPMENT RACK
  - A. Manufacturers: Chatsworth
  - B. General:
    - 1. Part no. 11807-X18
    - 2. Equipment racks shall be:
      - a. Constructed of painted (black) or anodized steel or aluminum.
      - b. Supplied with ground bar (19" wide by 1" high) and #6 AWG ground lugs.
      - c. Supplied with minimum of 12 releasable cable support ties (e.g. "hook and loop").
      - d. Supplied with spare screws (minimum of 50)
    - 3. Channel uprights shall be spaced to accommodate industry standard 19" mounting.
      - a. 4-Post wall- mount cabinet
      - b. Standard with 19" mounting space
      - c. Front and back rails to be moveable
      - d. Cable management devices or mounting brackets in rear
      - e. 25 rack units (RU) min. EIA/TIA tapped holes, alternating pattern
- 2.03 CABLE MANAGEMENT
  - A. Vertical and Horizontal cable managers
    - 1. Manufacturers: Chatsworth, Hubbell, B-Line, Panduit or product manufactured by the selected cabling system (Commscope/Systimax).
    - 2. Material: metallic construction, painted to match cabinets and patch panels (black)
    - 3. 6" vertical cable managers, accessible from both sides, having "fingers" both front and rear.

# PERMIT SET

4. 1 or 2 RU horizontal cable managers between every UTP patch panel as indicated on project documents.

#### 2.04 FLEXIBLE NONMETALLIC INNERDUCT AND FITTINGS

- A. Manufacturers: Carlon, Pyramid, Duraline
- B. General:
  - 1. Flexible Nonmetallic Innerduct shall be used:
    - a. As protection to fiber optic cables when installed in cable tray
    - b. As protection to fiber optic cables within TRs.
    - c. As raceway for Cat6 data cable to outlet boxes from accessible ceiling
  - 2. Flexible Nonmetallic Innerduct shall be 1-1/4" diameter for fiber and 1" for Cat6 data cable unless noted otherwise.
- C. Indoor Innerduct:
  - 1. Shall be corrugated
  - Non-plenum to be orange colored 2.
- D. Outdoor Innerduct shall be:
  - 1. Smooth outside and ribbed inside
  - 2. Rated for outdoor use
  - 3. Be Orange colored
- E. Plenum Rated Innerduct shall:
  - 1. Be fabricated of flame-retardant materials suitable for installation in plenum rated environments.
    - a. Meet requirements for flame propagation for listed optical fiber cables installed in spaces transporting environmental air.
  - Be White colored. 2.
- F. Flexible Fabric Innerduct:
  - Flexible Fabric Innerduct (FFI) shall be used as follows: 1.
    - a. To segment conduit(s), increasing their capacity for fiber optic and copper cable backbone runs within conduit.
    - b. Use 3-4 inch, 3 cell product with pull strings.
    - c. Manufacturer: MaxCell

#### 2.05 CABLE RUNWAY

- A. Manufacturers: Hoffman, CPI, B-Line, Homaco or product manufactured by the selected cabling system (Commscope/Systimax).
- B. Cable Runway shall be:
  - 1. Constructed of 0.065" thick steel
  - 2. Utilize tubular stringers to support rungs.
    - a. Stringers shall be 1-1/2" high.
    - b. Rungs shall be welded to stringers and shall be spaced 9" on center.
  - 3. Width(s) as shown on drawings.
  - 4. Painted with black epoxy to match cabinets.
  - Cabinets, free standing racks and cable runway shall all be of the same color 5.
- C. Cable Runway Accessories as recommended by manufacturer (to include, but not limited to):
  - 1. Butt Splice Kit
  - 2. Junction Splice Kit
  - Channel Rack-to-Runway Mounting Plate 3.
  - 4. Triangular Support Bracket, Steel
  - 5. Wall Angle Support Kit, Cable Runway
  - Foot Kit, Cable Runway 6.

- 7. Vertical Wall Brackets
- 2.06 MISCELLANEOUS MATERIALS
  - A. Telecommunications Ground Busbar (TGB)
    - 1. See section 27 05 26
    - 2. Manufacturers: CPI, Harger, B-Line
    - 3. Be wall mounted
    - 4. Pre-drilled with double-hole lug pattern
    - 5. See project documents for details and sizes
  - B. Power Devices
    - 1. Power Strips
    - 2. Uninterruptible Power Supplies (UPS)
      - a. Provided by owner unless noted otherwise on project documents
  - C. Plywood
    - 1. Plywood shall be provided by the EC if not already provided by the General Prime Contractor (GPC). The EC shall coordinate this requirement prior to bidding to determine installation responsibility.
    - 2. General
      - a. Provide plywood on all walls wider than 12"
      - b. <sup>3</sup>/<sub>4</sub>" x4'x8', standard plywood sheet size
      - c. Fire retardant treatment with verifying stamps
      - d. Grade A/C with A side mounted out, smooth finish, no splinters, dimples or open knots, no texture
      - e. No internal or external voids
      - f. Flat, not warped
      - g. Placed on 1.5" thick furring strips or 1.5" hat channel if mounted on concrete or CMU (so screws don't dead-end behind plywood when mounting equipment)
      - h. Aligned with studs if studs are present. Each edge of plywood shall be on a stud. Split studs at seams.
      - i. Mounted vertically, may start at 2" or 4" above floor to account for baseboard or to assist leveling. Does not want to be tight to floor (catches dirt and debris, floor is not always level or smooth)
      - j. All seams flush with each other on all surfaces, no warps, no uneven surfaces, no uneven edges at top, sides or bottom
      - k. Ceramic coated or stainless steel screws to resist corrosion and chemical interaction with firestop treatment of plywood
      - I. Screws to be minimum #12 size, wood screw threads, minimum 2" long, flat head, heavy-duty, Philips, Torx or square drive
      - m. Even pattern 16" O.C. horizontally and 24" O.C. vertically including all corners. (20) screws minimum every 4x8 sheet. Provide additional screws as required to counteract warping and to assure flush surfaces all around.
      - n. All screws to be set flush to plywood surface
      - o. Painted light (off-white, not gray) color, leave one fire stamp visible on every sheet
      - p. Mounted and painted prior to mounting of electrical equipment

# PART 3 - EXECUTION

3.01 FREE STANDING 2-POST RACK

- A. Provide equipment racks as shown on drawings.
- B. Racks shall be secured as recommended by manufacturer and braced with cable runway as shown on drawings. Bolt 2-post racks to floor using (4) bolts. Also secure top of 2-post racks to adjoining wall using short section of cable runway and appropriate rack to runway mounting kits, j-bolts and wall angle supports.
- C. Provide Horizontal and Vertical Cable Management on racks, one vertical manager for each side and three (2) 2-RU horizontal mangers for each cabinet (min) or more as required for routing patch cables.
- D. Provide ground bar in equipment racks.
- E. Bond rack mounted ground bar to telecommunications room ground bar.
  - 1. Racks and cabinets shall have individual grounding conductors from each rack bonded to TGB
  - 2. Daisy-chaining grounding conductors between racks or cabinets is not allowed.
- F. Coordinate with General Contractor for provision of <sup>3</sup>/<sub>4</sub>" fire retardant plywood on all walls. Coordinate this PRIOR TO BIDDING.
- G. Coordinate with Electrical Contractor for provision of power.
- H. Coordinate with Electrical contractor for division of labor installing the grounding and bonding system. This contractor is responsible for all grounding and bonding of all telecom equipment within the TR.

# 3.02 WALL-MOUNT EQUIPMENT RACK

- A. Provide equipment racks as shown on drawings.
- B. Provide Horizontal Cable Management in rack as required between path panels
- C. Provide ground bar in equipment racks.
- D. Bond rack mounted ground bar to telecommunications room ground bar.
  - 1. Racks and cabinets shall have individual grounding conductors from each rack bonded to TGB
  - 2. Daisy-chaining grounding conductors between racks or cabinets is not allowed
- E. Coordinate with General Contractor for provision of <sup>3</sup>/<sub>4</sub>" fire retardant plywood on all walls.
- F. Coordinate with Electrical Contractor for provision of power.
- G. Coordinate with Electrical contractor for division of labor installing the grounding and bonding system. This contractor is responsible for all grounding and bonding of all telecom equipment within the TR.

#### 3.03 CABLE MANAGEMENT

A. Cable management must be planned carefully to avoid unnecessary cable crossovers and intertwining. Use Velcro style cable tie wraps at 24 inch intervals in TRs, on wall fields and in cable trays with TRs.

# 3.04 FLEXIBLE NONMETALLIC INNERDUCT AND FITTINGS

- A. Innerduct shall extend to equipment racks at system endpoints.
- B. Where not installed in continuous length, splice innerduct segments using couplings designed for that purpose.
- C. Provide quick connect adapters on end of innerduct where innerduct contacts junction boxes or fiber optic patch panels.
- D. Empty innerduct shall be equipped with pull cord and capped at both ends.
- E. Provide Plenum-rated innerduct under all raised floors and in ceiling plenums.
- F. Label innerduct at 35 ft. intervals in ceilings with tags indicating cable type and cables contained therein.
- G. Label innerduct on every floor in every riser shaft at eye level according to fiber type, fiber count, destination at both ends and installation date. Example: 12 MM/Floor 1 MTR to Floor 2 TR, 10/25/2012.
- H. Pull strings shall extend beyond end of innerduct and be tied off securely for access.
- I. Label each end of pull string with distinguishing label for each innerduct so that one end can be traced to the other. Simple numbering or lettering is sufficient.

# PERMIT SET

- J. Fasten innerduct raceway to building structure at 4-6 foot intervals in ceiling to prevent movement and shifting of innerduct during cable installation.
- K. Provide innerduct for fiber optic cables passing between floors from one TR to the next.
- L. For all 4" conduits provided for communications cables, but not currently used for cable installation, provide (2) 3-cell FFI products (6 pathways) from end to end for future cable installations.

# 3.05 CABLE RUNWAY

- A. Provide runway and accessories necessary for complete system.
- B. Size and layout of runway shown on drawings.
- C. Install runway and accessories per manufacturers' installation instructions.
  - 1. Use only runway accessories manufactured and recommended by runway manufacturer
  - 2. No custom-built brackets or devices allowed
- D. Provide 3/8" threaded rods from structural ceiling for support of 12" wide or smaller runway as required for ceiling mount.
- E. Provide 1/2" threaded rods from structural ceiling for support of runway greater than 12" in width.
- F. Support from building structure.
- G. When runway is installed on (adjacent to) walls, use triangular support brackets, not threaded rod.
- H. Maximum allowable deviation of runway from level horizontal plane measured across length of tray shall be 1/2", with the tray loaded to capacity.
- I. Fasten runway to top of equipment racks within TRs with equipment manufactured for this purpose.
- J. Use 3" spacers on top of racks to mount cable runway. Nominal height of cable runaway above floor with use of spacers will be 7'-3". Be sure runway clears all door swings.
- K. Provide cable dropouts at all equipment rack locations, elevation changes 6" or more, and as shown on drawings.
- L. Bond runway components together using manufacturer's standard accessories. Grind off paint as required to obtain positive electrical connection, or use washers manufactured for that purpose. Bond runway to TGB.
- M. Fasten cables to runway with Velcro straps within TRs at intervals not to exceed 4 ft.
- 3.06 MISCELLANEOUS EQUIPMENT
  - A. Provide TGB in every TR as indicated.
    - 1. Mount at 18" AFF
    - 2. Coordinate with electrical contractor as required.
  - B. Cable Management Straps
    - 1. Cables shall be secured with reusable hook and loop straps.
    - 2. Provide Cable Management on 2-post racks
    - 3. Provide cable management both vertically and horizontally on racks as indicated on project documents.
  - C. Provide any/all conduit sleeves required to enter/exit TR to adjacent ceiling space that the EC has not already provided.
  - D. Provide extra heavy cable tie mounts on TR plywood and riser walls at 24 inch intervals to support cable. Must utilize #8 or #10 screws – NOT ADHESIVE. Similar to Panduit TMEH-S10-Q0. Other brands: HRP, Uline.

END OF SECTION

# SECTION 27 1310 – BACKBONE COPPER CABLE AND EQUIPMENT

#### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Copper Backbone Cable
- B. Communications Cables
- C. Cable Terminations
- D. Primary Protection
- E. Splice Equipment
- F. Backbone Coax Cable
- G. Cable Identification

#### 1.02 RELATED WORK

- A. Section 27 05 00 Common Work Results for Communications Systems
- B. All references including Division 26 apply.
- C. The work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements. This work is also subject to all requirements of Division 26 of these specifications wherever applicable to work under this section.

## 1.03 SUBMITTALS

- A. Submit shop drawings for equipment under this section.
- B. Submittals should be grouped to include complete documentation of related systems, products and accessories in a single submittal. If provided electronically in PDF format, one Specification Section should equal one file or file name. Do not scan multiple Specification Sections into one file.
- C. Where applicable, dimensions shall be marked in units to match those specified.
- D. Submittals shall be original catalog sheets or photocopies thereof. Facsimile (fax) sheets or printed web pages shall not be accepted. Circle appropriate part number with black pen. Circle appropriate picture if more than one appears on page. Contractor shall indicate on submittal the system(s) served by each cable submitted.
- E. Submit manufacturer's installation instructions.
- F. Work shall not proceed without Engineer's approval of submitted items.

#### 1.04 REFERENCE STANDARDS

- A. Installation requirements are found in the following the American National Standards Institute (ANSI) and Electronic Industries Association/ Telecommunications Industry Association (EIA/TIA) Standards.
- B. ANSI/TIA/EIA-568-B Commercial Building Telecommunications Cabling Standard
- C. ANSI/EIA/TIA-569-B-2004 Commercial Building Standard for Telecommunications Pathways and Spaces
- D. ANSI/TIA/EIA-606-A-2002 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

# 1.05 QUALITY ASSURANCE

- A. Full compliance with engineered design and specifications is required.
- B. Performance criteria specified in references cited in Paragraph 3.02 shall be met. Test data shall verify system performance.

# PERMIT SET

# 1.06 PERFORMANCE TESTING

- A. Testing of all installed cable and equipment shall be performed by the contractor as soon as practical after equipment is installed.
- B. Contractor shall use current, state-of-the-art, industry standard test equipment.
- C. Testing shall be accomplished before notifying Engineer of substantial completion and before punch list is performed.

#### 1.07 WORK BY OWNER

A. The Local Exchange Carrier may provide certain cross connections to LEC owned equipment.

#### 1.08 WORK INCLUDES

A. Complete backbone copper cable system utilizing standard telephone cable equipment. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of copper backbone infrastructure as described on the Drawings and/or required by these specifications.

#### 1.09 DESCRIPTION

A. This Section includes specifications for 100 ohm balanced twisted pair copper backbone cable and connections as typically used in telephone systems.

#### 1.10 CODE COMPLIANCE

- A. All work and materials shall comply with the most recent rules, codes, and regulations, including but not limited to the following.
  - 1. Occupational Safety and Health Act Standards (OSHA)
  - 2. NFPA 70 National Electrical Code (NEC)
  - 3. ANSI/IEEE C-2 National Electrical Safety Code
  - 4. All other applicable Federal, State, and local laws and regulations.

# 1.11 MANUFACTURER'S INSTRUCTIONS

- A. When specified in Specification Sections, submit manufacturer's printed instructions for delivery, storage, assembly, installation, adjusting, and finishing, in quantities specified for Shop Drawings and Equipment Brochures.
- B. Unless otherwise stated, where installation requirements identified in Reference Standards conflict with the manufacturer's recommendations, the more restrictive shall be apply.
- C. Bring to the attention of the Owner and HCIS conflicts between manufacturer's instructions and Contract Documents.

#### PART 2 - PRODUCTS

#### 2.01 COMMUNICATIONS CABLES

- A. Communications cables shall be type and size (number of pairs) identified for the installation of the various communications systems. Provide standard multi-pair, color coded, telephone cable.
- B. Communications cables shall be Listed and Approved for intended use by a nationally recognized testing laboratory. All cable shall be of Type specified by the NEC for use in plenum, non-plenum, and riser spaces.
- C. Communications cables installed in cable trays shall be APPROVED for use in such and shall be of fireresistive construction.

# PERMIT SET

- D. Communications cable suitable for use in ducts, plenum, and other space used for environmental air shall be UL Listed as being smoke resistant, shall be Teflon-coated and shall be classified as type CMP communications cable.
- E. Communications cable suitable for use in vertical shafts shall be UL Listed for use in such space and shall be classified as type CMR communications cable.
- F. CM rated cables entering from outside the building must comply with the 50 foot rule. That is, cable must be terminated, protected or transitioned within 50 feet of the outdoor entrance or 50 feet from the emergence of approved conduit.
- G. Approved conduit from outside the building consists of either rigid steel conduit or intermediate steel conduit. EMT does not qualify. Outdoor cable entering a building within EMT conduit must still comply with the 50 foot rule.

# 2.02 COPPER BACKBONE CABLE

- A. Copper Telephone Backbone Cable for indoor application: Type CMR, 24 AWG twisted, solid annealed copper conductors insulated with PVC skin over expanded polyethylene, having an overlapped corrugated aluminum shield (ARMM Type), fire-resistant FR-PVC plastic jacket, conforms to Bell Laboratories specification L-780011 and ANSI/TIA/EIA 568-A, and Class 3 Category-3 performance category.
  - 1. Cable used in outdoor applications shall be rated for that application (AFMW type).
  - 2. Outdoor cable shall have gel filling or water block tape to prevent ingress of water.
  - 3. Cable used in pure riser applications shall be shielded ARMM type without blocking.
- B. Acceptable Manufacturers: Commscope, Mohawk, General, Superior Essex Belden. Size as specified on the Drawings.
- C. Copper backbone cable shall be rated for the environment in which installed.
- D. Copper backbone cable shall be provided by the Communications Contractor.
- E. Backbone cable shall meet following minimum requirements:

	- 0					
Size	24 AWG solid annealed copper pairs					
Number of Pairs	As shown on Project Documents					
Mutual Capacitance	<u>≤</u> 6.6 nF/100m					
Impedance	100 ohms ± 15%					
Frequency (MHz)	0.772	1	4	8	10	16
Attenuation (dB/100m@20° C)	6.0	7.0	15	23	26	35
Worst Pair NEXT (dB)	43	42	34	32	31	28
Jacket Color	Black or Grey					
Jacket Type	PVC – ALVYN sheath					
Cable Rating	NEC Article 800 Type CMR, UL listed					
Shield	Shield Overall continuous corrugated aluminum bonded to outer jacket					

- F. Cable shall be standard exchange type telephone cable. This is defined as paired multi-conductor, thermoplastic insulated, copper cable characterized by a mutual capacitance of 0.083 microfarads per mile at 1000 Hz.
- G. Identify conductors by insulation color.
- H. Color code shall follow industry standard of 10 distinctive colors to identify 25 pairs.
- I. Marking of each mate of the primary conductor in pair with color of that primary conductor is optional.
- J. When cables of larger than 25 pairs are required, cable core shall be assembled into 25-pair sub-units.
- K. Cables with over 600 pairs shall have 25-pair binder groups combined into super units.
  - 1. Wrap super units with solid color thread that follows primary color scheme of white, red, black, yellow and violet.
  - 2. Maintain binder color code integrity whenever cables are spliced.

- 2.03 CABLE TERMINATIONS
  - A. Provide 110 style high density connection blocks with (IDC) connectors
  - B. Acceptable manufacturers: Commscope, Panduit, Siemens
    - 1. Cross connect blocks shall:
      - a. Be designed to maintain cable pair twists as closely as possible to point of mechanical termination.
      - b. Identify pair position by color designation.
        - 1) Colors shall be Blue, Orange, Green and Brown for Station Cables and Blue, Orange, Green, Brown and Slate for Backbone Voice Cables.
    - 2. Each horizontal row of cross connect blocks shall be capable of terminating one 25 pair binder group of Backbone Voice Cable, or six 4 pair Station Voice Cables.

# 2.04 PRIMARY PROTECTION

- A. Surge Protection Modules
  - 1. 5-pin, solid state protector modules
  - 2. Provide transient and power fault protection
  - 3. Nanosecond response time
  - 4. Integrated test points
  - 5. UL listed
  - 6. Meet or exceed Telecordia Statndards
  - 7. Refer to CIRCA brand 4B1FS-240
  - 8. Use only where owner cable is run between bldgs. The Telco service provider (LEC or ISP) should provide their own protection for their entrance cable.

# 2.05 SPLICE EQUIPMENT

- A. Manufacturer: 3M
- B. Indoor
  - 1. One step small copper closure
  - 2. Dome copper closure
  - 3. Vault and riser copper closure
- C. Outdoor
  - 1. Watertight copper closure
  - 2. Buried copper closure
  - 3. Aerial copper closure

#### 2.06 BACKBONE COAXIAL CABLE

- A. Inter-Building
  - 1. Manufacturers: CommScope, General.
  - 2. .750 Backbone Cabling
  - 3. Inter-building coaxial backbone cabling shall be .750 trunk type.
  - 4. Basic Construction
    - a. Center conductor: Copper-clad aluminum (0.167" nominal outer diameter)
    - b. Dielectric: Gas injected foam polyethylene.
    - c. Outer shield: Continuous, solid aluminum (0.750" nominal outer diameter, 0.035" nominal thickness)
    - d. Jacket: Medium density polyethylene (0.820" nominal outer diameter, 0.035" nominal thickness)
      - 1) Jacket shall be free of pinholes, cracks and blisters/
      - 2) Jacket shall contain carbon black to ensure ultraviolet light stability (UV).
    - e. Specifications:

- 1) Impedance:  $75 \pm 2$  ohms
- 2) Capacitance:  $15.3 \pm 1.0 \text{ pf/ft.}$
- 3) Velocity of Propagation: 87% nominal
- 4) Minimum Structural Return Loss: -30 dB (5-1000 MHz)
- 5) Maximum Attenuation @ 68°F: 0.37 dB/100 ft. (55 MHz)
- 6) 48 dB/100 ft. (750 MHz)
- 7) Cable Rating: Type CATVR
- B. Intra-Building Riser
  - 1. .500 Backbone Cabling (half inch hard line)
  - 2. Basic Construction
    - a. Center conductor: Copper-clad aluminum (0.109" nominal outer diameter).
    - b. Dielectric: Gas injected foam polyethylene.
    - c. Outer shield: Continuous, solid aluminum (0.500" nominal outer diameter, 0.024" nominal thickness)
    - d. Jacket: Flame retardant polyethylene (0.560" nominal outer diameter, 0.030" nominal thickness)
      - 1) Jacket shall be free of pinholes, cracks and blisters.
      - 2) Jacket shall contain carbon black to ensure ultraviolet light stability (UV)
    - e. Specifications:
      - 1) Impedance:  $75 \pm 2$  ohms
      - 2) Capacitance:  $15.3 \pm 1.0$  pf/ft.
      - 3) Velocity of Propagation: 87% nominal
      - 4) Minimum Structural Return Loss: -30 dB (5-1000 MHz)
      - 5) Maximum Attenuation @ 68°F: 0.54 dB/100 ft. (55 MHz)
      - 6) 16 dB/100 ft. (750 MHz)
      - 7) Cable Rating: Type CATVR
- C. Riser and Distribution Coaxial Cable
  - 1. Manufacturers: CommScope, Belden.
  - 2. Cable shall be RG-11 type.
  - 3. Construction (RG-11 type, quad-shield):
    - a. Center Conductor: 14 AWG copper-clad steel (0.064" nominal outer diameter).
    - b. Dielectric: Gas expanded (foamed) polyethylene (0.280" nominal diameter).
    - c. First shield: Aluminum-polypropylene-aluminum laminated tape with overlap bonded to dielectric.
    - d. Second shield: 34 AWG aluminum braid wire (60% coverage).
    - e. Third shield: Non-bonded foil shield.
    - f. Fourth shield: 34 AWG aluminum braid wire (60% coverage)
    - g. Jacket: Flame retardant PVC (0.405" nominal outer diameter). Jacket shall contain carbon black to ensure ultraviolet light stability (UV).
    - h. Specifications:
      - 1) Impedance:  $75 \pm 3$  ohms
      - 2) Velocity of Propagation: 87% nominal
      - 3) Maximum Attenuation @ 68°F: 0.96 dB/100 ft. (55 MHz)
      - 4) 65 dB/100 ft. (750 MHz)
      - 5) Cable Rating: Type CATVR
- 2.07 CABLE IDENTIFICATION
  - A. Cable labels
    - 1. Manufacturer: Brady, Panduit, Silver Fox or same as cable system manufacturer

10/24/2

- 2. Type: adhesive or tie-wrap
- 3. White background with black, bold, readable letters, machine printed

# PART 3 - EXECUTION

#### 3.01 CABLE INSTALLATION

- A. Refer to project documents for cable routing.
- B. When breaking out any multi-pair copper cable of 50 pairs or greater for splicing or termination, the binder groups shall have color coded cable ties attached to the cable at the point of fanout from super groups for splicing, and at the point of fan-out for termination on termination blocks.
- C. The Contractor shall ensure the cables are pulled into the ducts in a manner observing the bend radii and tension restrictions of the cable.
- D. The Contractor shall use appropriate shoes, guides, wheels and lubricants to prevent damage to the cable jacket and sheath during installation.
- E. All pairs spliced shall be tested and all splice-related faults cleared prior to sealing the closure assembly if required.
- F. Provide Backbone Voice Cable from MTR to TRs. Size cables as shown on Project Documents.
- G. Terminate cables on backbone voice cable blocks at all TRs.
- H. Cables shall have pair twists maintained to within 1" of termination.
- I. Remove cable jacket only to extent required to make terminations.
- J. Install shield bond connectors to the shields of all cables terminated at the Protector Panels or ground bars. Bond all cable shields to ground.
- K. Bond all cable shields in Data Center, MTR or MDF to TMGB. Bond only at one end of shield at head end location. Affix label at far end of cable indicating that bonding connection to ground has been made at MTR.

#### 3.02 COMMUNICATIONS CABLING TESTING

- A. Individually test all pairs and cable shields from both ends of the cable for continuity, power faults, and ground-faults. Correct all shorts, opens, crosses, bad terminations, foreign voltages, grounding problems, sheath continuity problems, etc.
- B. In addition, provide loop resistance measurements in ohms and dB loss at 1 KHz and calculated dB loss at 8 KHz and 256 KHz on the first pair of each binder group.
- C. Owner/engineer is to be notified at least 48 hours prior to testing to allow observation at Owner/engineer discretion. If the Owner/engineer confirms the intention to observe, a reasonable starting time will be agreed upon. Should the Owner/engineer not be present at the scheduled commencement time, the Contractor may begin testing as scheduled.

# 3.03 WIRE AND CABLE IDENTIFICATION

- A. Cable sheath
- B. Cable sheath shall be labeled approximately 12-24" from cable termination of wall field.
- C. Label shall be on a plastic tag, which is tie-wrapped to cable sheath, or placed on adhesive labels, which are stuck to the cable sheath.
- D. If adhesive labels are used, the cable sheath shall be cleaned thoroughly before applying the label. Afterwards, a clear cellophane tape covering should be placed over the label to protect it and maintain adhesion to sheath.
- E. The label shall identify cable (CA) number, total number of pairs in cable, and date installed. The label shall also indicate the near and far end termination locations.
- F. Example:



1-50	
Bldg 1 to Bldg 2	
August, 2012	

- a. Backbone Voice Riser Cable (from Main Telecom Room (MTR) to other TRs)
- b. Labeling shall meet all general requirements and the following:
- c. Designation strips on the 110 blocks shall be labeled in 25 pair groups indicating destination room number far end (including floor) and pair counts. The far end room number shall be repeated on every designation strip.
- 2. Backbone voice riser cable designation strips shall be labeled as follows:
  - a. TR XXX-YY where:
- XXX = Far end room number

YY = Pair number

3. Example MTR to upper TR:

		TR 201-01	0
		TR 201-026	050
4.	Example	FR to Main TR:	
		MTR 106-01	025
		MTR 106-026	050

- 5. Cable sheath
  - a. Cable sheath shall be labeled approximately 24" from cable termination on wall field.
  - b. Label shall be on a plastic tag, which is tie-wrapped to cable sheath, or placed on adhesive labels, which are stuck to the cable sheath.
  - c. If adhesive labels are used, the cable sheath shall be cleaned thoroughly before applying the label. Afterwards, a clear cellophane tape covering should be placed over the label to protect it and maintain adhesion to sheath.
  - b. The label shall identify cable from and to locations, total number of pairs in cable, and date installed.
- 6. Example MTR to TR:

7. Example TR to MTR:

MTR 106 to TR 3164
1-200
10/2012
TR 3164 to MTR 106
1-200
10/2012

END OF SECTION
## SECTION 27 1320 – FIBER OPTIC CABLE AND EQUIPMENT

#### PART 1 – GENERAL

#### 1.01 SECTION INCLUDES

- A. Fiber Optic Cable
- B. Fiber Optic Connectors
- C. Fiber Optic Patch Panels
- D. Splice Center
- E. Miscellaneous Materials

#### 1.02 RELATED WORK

- A. Section 27 05 00 Common Work Results for Communications Systems
- B. All references including Division 26 apply.
- C. The work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements. This work is also subject to all requirements of Division 26 of these specifications wherever applicable to work under this section.

## 1.03 SUBMITTALS

- A. Submit product data for equipment provided under this section.
- B. Submittals should be grouped to include complete documentation of related systems, products and accessories in single submittal. If provided electronically in PDF format, one Specification Section should equal one file or file name. Do not scan multiple Specification Sections into one file.
- C. Dimensions shall be marked in units to match those specified.
- D. Submittals shall be original catalog sheets or photocopies thereof. Facsimile (fax) sheets or printed web pages shall not be accepted. Circle appropriate part number with black pen. Circle appropriate picture if more than one appears on page. Contractor shall indicate on submittal the system(s) served by each cable submitted.
- E. Submit manufacturer's installation instructions.
- F. Prior to completion of final fiber optic test results, submit sample test results or three fibers to engineer for review and approval. Failure to submit sample tests indicating sample results and formatting may be cause for rejection of test results

#### 1.04 REFERENCE STANDARDS

A. BICSI TDMM Telecommunications Distributions Methods Manual (Curre	t edition)
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- B. TIA/EIA 455-21-A Mating Durability for Fiber Optic Interconnecting Devices
- C. TIA/EIA 526 14 Optical Power Loss Measurements of Installed Multimode Fiber Cable Plants
- D. TIA/EIA 568-B.1-B.3 Commercial Building Telecommunications Cabling Standard
- E. TIA/EIA 569-B Commercial Building Standard for Telecommunications Pathways and Spaces
- F. TIA/EIA 606 The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
- G. TIA/EIA 607 Commercial Building Grounding and Bonding Requirements for Telecommunications

 H. UL 910
 Texts for Flame Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables used in Spaces Transporting Environmental Air
 I. UL-1666
 Tests for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

## 1.05 PERFORMANCE TESTING

- A. Testing of all installed cable and equipment shall be performed by the contractor as soon as practical after equipment is installed.
- B. All fibers shall be tested with state-of-the-art, industry standard test equipment by personnel properly trained to operate equipment.
- C. Testing shall be accomplished before notifying Engineer of substantial completion and before punch list is performed.

## 1.06 WORK INCLUDES

- A. All labor and materials for a complete fiber optic backbone cable system utilizing multimode (and single mode if required) fiber cables. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of fiber optic infrastructure as described on the Drawings and/or required by these specifications.
- B. Any part numbers provided in this specification are included for reference only or as an example of the type and quality of system to be installed. It shall be the contractor's responsibility to supply a system in excellent working order, which fully meets the criteria set forth in the general description as well as the listed specifications. It shall be the contractor's responsibility to verify the correctness of parts lists and specifications for use of equipment specified, in the manner specified, and for conditions as they actually exist on the job site. Equipment not mentioned herein or shown on the drawings but necessary to meet this requirement shall be provided and shall be so indicated in the initial Bill of Materials, or shop drawing submittals, or shall be provided without claim for additional payment.

## PART 2 – PRODUCTS

- 2.01 FIBER OPTIC CABLE
  - A. Manufacturers: CommScope/SYSTIMAX, Corning, Belden, OFS, OCC or approved equal.
  - B. Multimode fiber shall be: 50-micron laser optimized, OM3, plenum rated fiber optic cable.
  - C. Interlocking aluminum armor jacket
  - D. Optical fibers shall:
    - 1. Be sufficiently free of surface imperfections and occlusions to meet optical, mechanical, and environmental requirements of this specification.
    - 2. Have been subjected to minimum tensile proof test by fiber manufacturer equivalent to 100 kpsi.
  - E. Factory optical fiber splices are not allowed.
  - F. Coatings shall be mechanically strippable without damaging optical fiber.
  - G. Indoor Fiber Optic Cable: Cable shall:
    - 1. Be suitable for installation in free air, in building risers, in conduit, in cable tray and in innerduct.
    - 2. Be dielectric materials (no conductive materials).
    - 3. Be listed as being suitable for use in vertical run in shaft or from floor to floor and shall be listed as having fire-resistant characteristics.
    - 4. Be listed as suitable for use in air handling spaces (plenum rated).
    - 5. Meet the following specifications:
      - a. Jacket Material: PVC (OFNR) or as required by ceiling type
        b. Buffer Diameter: 250 -900 microns

- c. (Multi-Mode):
- d. Cable Rating:
- e. Strength Member:
- f. Storage Temperature:
- g. Operating Temperature:
- h. Humidity Range:
- i. Maximum Tensile Strength:
- j. Bending Radius:

k. No Load:

Slate/Grey/Aqua OFNR

Aramid Yarn, fiberglass

-40° to +70°C (no irreversible change in attenuation)

-20° to +70°C (no irreversible change in attenuation)

- 0 to 100%
- During Installation 2700 N (no irreversible change in
- attenuation). Long Term 1000 N

During Installation - 20 times cable diameter

10 times cable diameter

- H. Armored Cable
  - 1. Aluminum interlocking armor, removable to expose intact inner fiber cable
  - 2. UL listed in accordance with NEC 770.179(a) for use in ducts, plenums and air handling spaces
  - 3. Fluorpolymer inner and outer jackets
  - 4. Aqua color jacket to identify 50 micron fiber

## 2.02 FIBER OPTIC CONNECTORS

- A. Connectors shall:
  - 1. Be LC-type for single mode.
  - 2. Be LC-type for multimode.
  - 3. Accept fibers having clad diameter of 125 microns.
  - 4. Accept fibers having buffered diameter of 900 microns.
  - 5. Sustain minimum of 200 mating cycles.
  - 6. Meet the following performance criteria:

51	
TEST PROCEDURE	MAX. ATTENUATION CHANGE
Cable Retention (FOTP-6)	0.2 dB
Durability (FOTP-21)	0.2 dB
Impact (FOTP-2)	0.2 dB
Thermal Shock (FOTP-3)	0.2 dB
Humidity (FOTP-5)	0.2 dB

- B. Connector ferrule shall be ceramic.
- C. Optical fiber within connector ferrule shall be secured with adhesive.
- D. Optical fiber within connector ferrule shall be mechanically secured and index matching gel shall be included in connector.
- E. Attenuation per connector shall not exceed 0.3 dB.

## 2.03 FIBER OPTIC PATCH PANELS

- A. Patch Panels shall be:
  - 1. 24 to 48 strand capacity
    - a. Accepts 6 or 12 cartridge panels
  - 2. Be enclosed assemblies.
  - 3. Incorporate hinged or retractable front cover.
  - 4. Be rack mountable on standard TIA/EIA 19" equipment racks.
  - 5. Provide for strain relief of incoming cables.
  - 6. Provide for labeling of individual connectors
  - 7. Incorporate radius control mechanisms to limit bending of fiber to manufacturer's recommended minimums of 1.2", whichever is larger.
  - 8. Provide protection to both "facilities" and "user" sides of couplings.

- 9. Be configured to require only front access when patching.
- 10. Include provisions for permanent labeling of fiber optic cables. Labeling shall be accessible from front of patch panel and shall not require disassembly of patch panel enclosure or removal of front cover.
- B. LC-type couplings shall be mounted on assembly that snaps into patch panel enclosure. This assembly shall be designed to accept variety of coupler types including, ST, SC, duplex SC and high-density mini-connectors.
- C. Access to inside of panel enclosure during installation shall be from front and rear. Panels that require any disassembly of cabinet to gain entry will not be accepted.
- D. Incoming cables shall not be accessible from patching area of panel. Enclosure shall provide physical barrier to access of such cables.
- 2.04 SPLICE CENTER
  - A. Cable shall be installed continuous without breaks, interruption or splices. Splicing not allowed unless otherwise noted.

## 2.05 MISCELLANEOUS MATERIALS

- A. Fiber Patch Panel Organizer
- B. Fiber Jumper Storage Shelf

## PART 3 – EXECUTION

#### 3.01 FIBER OPTIC CABLE

- A. Provide backbone fiber optic cable as shown on drawings.
- B. Route backbone fiber optic cable in innerduct. Ensure innerduct is of sufficient length to avoid innerduct retreating into the conduit during installation of fiber optic cables. Innerduct should extend a minimum of 2' beyond conduit at pull box point of entry at completion.
- C. Fiber terminations to TRs may be made using other means including quick connects or mechanical means.
- D. Fiber strands shall terminate on Fiber Optic Connectors mated to couplings mounted in Fiber Optic Patch Panels.
- E. Provide cable slack in each backbone fiber optic cable.
  - 1. Slack shall be in addition to length of fiber required for termination requirements. a. Store cable slack in enclosure designed for this purpose.
  - 2. Slack required shall be as follows:
    - a. Backbone Intra-Building:
      - 1) Minimum of 5 meters (each cable if applicable) coiled and secured at one end in MDF.
  - 3. Backbone Inter-Building:
    - a. Minimum of 15 meters (each cable if applicable) coiled and secured at one end in MDF.
- F. Fibers with coatings <900 microns shall be furcated (fanned-out) to minimum of 900 microns before termination.
  - 1. Provide buffer tube fan-out kits for fibers terminated in patch panel couplings.
  - 2. Provide 2.9 mm subunit fan-out kits for fibers not terminated in patch panel couplings.
- G. Visually inspect cables for cuts, blisters and abrasions during installation.
- 3.02 CABLE ROUTING
  - A. Run cabling in cable tray pathways provided, or as designated on floor plans, and support from building structure.

## PERMIT SET

- B. Cable shall be free of tension at both ends. In cases where cable must bear stress, provide Kellum grips to spread stress over longer length of cable.
- C. Support armored cable every 48-60" on center.

## 3.03 FIBER OPTIC CONNECTORS

- A. Follow manufacturer's guidelines for splices, pigtails and connector type provided.
- B. Clean connectors with lint-free pad saturated with 90% to 100% isopropyl alcohol after fiber termination. Wipe with dry, lint-free pad and blow end face with compressed air for minimum of 5 seconds.
- C. Insert connectors into patch panel mounted couplings. Provide dust caps for couplings.

## 3.04 FIBER OPTIC PATCH PANELS

- A. Provide Fiber Optic Patch Panels and coupling assemblies at TR's.
- B. Provide blank covers for unused coupling assembly spaces in panels.
- C. Provide patch panels and horizontal cable management in 19" equipment racks and mount according to manufacturers' recommendations.
- D. Provide LC type couplings in coupling assemblies and mount coupling assemblies and blank covers in patch panels.
- E. Clean couplings with foam swab and isopropyl alcohol prior to connector insertion. Blow dry with compressed air.
- F. Provide minimum of four (4) screws to secure each patch panel onto rack.
- G. Route armored cable all the way to the patch panel before breaking out cable. Use grommet on end of armored jacket to protect fiber from damage.

## 3.05 TESTING

- A. General:
  - 1. Fibers utilized in installed cable shall be traceable to manufacturer.
  - 2. Contractor shall detail proposed test plan for each cable type, including equipment to be used, test frequencies and wavelengths, etc.
  - 3. Test results shall include record of wavelength, fiber type, fiber and cabling number, measurement direction, test equipment and model number, date reference setup and operator.
  - 4. End-to-end performance tests are required for all cables, all strands.
  - 5. Test results shall be matched to individual fiber labels provided on patch panels. Every test performed and recorded shall be traceable to individual fibers or duplex connectors. Test results labeled generically will not be accepted.
  - 6. Provide power meter test results for ALL fibers and OTDR test results only for longer fibers (see below). Repair or replace any defective fibers.
- B. Pre-Installation Testing
  - 1. Submit cable manufacturer's test report for each reel of cable provided.
  - 2. Test reports shall include manufacturers on-reel attenuation test results at 850 nm and 1300 nm for each multi-mode optical fiber and 1310 nm and 1550 nm for each single mode optical fiber prior to shipment from manufacturer.
  - 3. Perform continuity test of fiber cable reels delivered to site.
  - 4. Verify fiber attenuation and length values as specified on cable data sheets supplied with cable reels.
  - 5. Perform tests in one direction at 1300 nm (multi-mode fibers) and 1550 nm (single mode fibers).
  - 6. On-the-reel Bandwidth performance as tested at factory shall be provided upon request.
  - 7. Visually inspect reels and packaging for damage.
  - 8. Contractors not performing this test do so at their own risk. Contractor is liable to replace all defective fiber.
- C. Post-Installation Testing:

## PERMIT SET

- 1. Upon completion of cable installation and termination, the Fiber Optic cabling shall be tested to include:
- 2. Optical Attenuation ("Insertion Loss" Method). Every installed cable shall be tested using this method, no exceptions.
- 3. Optical Attenuation shall be measured on all terminated optical fibers in both directions of transmission using the "Insertion Loss" method. Measurement shall be inclusive of the optical connectors and couplings installed at the system endpoints. Minimum 2 meter access jumpers fabricated from the same fiber under test shall be used at both the transmit and receive ends to insure that an accurate measurement of connector losses is made.
- 4. Multi-mode fibers shall be tested in accordance with the EIA/TIA 526-14A, Method B at 850 plus or minus 30 nm. Single mode fibers (if applicable) shall be tested in accordance with the EIA/TIA 526-7-1998. Method A.1. Testing shall be at 1300 plus or minus 20 nm.
- 5. Attenuation of optical fibers shall not exceed the values calculated as follows:
- Attenuation (max.) = (2 x C) + (L x F) +SdB where C is the maximum allowable Connector Loss (in dB), L is the length of the run (in kilometers) and F is the maximum allowable fiber loss (in dB/km). S is the total splice loss (# of splices \* max. attenuation per splice).
- 7. Provide test results in an orderly format (spreadsheet) that matches each test result with identifiable fiber label on patch panel.
- D. Verification of Link Integrity (OTDR)
  - 1. Optical Time Domain Reflectometer (OTDR):
  - 2. OTDR tests are required only for backbone cables of 300 feet or longer.
    - a. Properly calibrate tester per manufacturer's recommendations.
    - b. For short lengths of fiber (under 2,000 feet) set a short pulse width to avoid overpowering device and causing excessive reflections and backscatter.
    - c. Measure connector insertion losses at 850 nm and 1300 nm for multimode fibers and 1310 nm and 1550 nm for single mode fibers.
    - d. If "gainers" appear, re-test fiber in BOTH directions. Average test results in both directions to cancel out positive and negative readings.
    - e. Engineer reserves the right to require OTDR testing in BOTH directions.
    - f. OTDR traces shall be performed using access jumpers at the transmit and receive ends.
    - g. Traces shall be examined for continuity and anomalies to confirm fiber link performance.
    - h. Launch cord shall be minimum 100 ft. long, or as noted by test equipment manufacturer.
    - i. Traces shall be examined for continuity and anomalies to confirm fiber link performance.
    - j. Provide test results in an orderly format (spreadsheet) that matches each test result with identifiable fiber label on patch panel. GENERIC TEST LABELS NOT MATCHING ACTUAL LABELS IN THE FIELD WILL NOT BE ACCEPTED. OTDR TEST LABELS SHALL MATCH ONE-FOR-ONE POWER METER TEST RESULT LABELS WHICH SHALL ALSO MATCH LABELS ON PATCH PANELS. JOB WILL BE REJECTED IF LABELS ARE NOT CONSISTENT AND EASILY CROSS-REFERENCED TO LABELS IN THE FIELD ON PATCH PANELS, CONNECTOR PANELS AND CABLE SHEATHS.
    - k. Scale shall be set and cursors placed to show principally that portion of the trace that is under test. Adjust scale so that useless scatter beyond section of interest is not shown or outside of cursor field. Also adjust scale so that both launch cords are visible.
    - I. All OTDR tests shall be consistently presented:
      - 1) Format
      - 2) Scale
      - 3) Units
      - 4) Cursor placement
      - 5) Field of view

- m. Pre-test acceptance.
- n. Prior to completion of final power meter and OTDR tests, provide to engineer for review three sample test results of both of power meter tests and OTDR tests. Consistent formatting is important.
- After engineer has provided comments and adjustments to contractor (if required), final tests may be completed. If this step is not taken, contractor risks rejection of entire fiber optic installation and test results.

## 3.06 LABEL IDENTIFICATION

- A. In addition to requirements in this Article, comply with applicable requirements in Division 26 Section "Electrical Identification".
- B. General Label Requirements:
  - 1. Mechanically print and install all labels per drawing details.
  - 2. Format: Select font size to be readable and to fit all information required without overlap of text. Font: Helvetica, Bold.
  - 3. Use all capital letters. Use a one-line format.
  - 4. Clean all surfaces prior to attachment of any label. Follow manufacturer's recommendations for cleaning and affixing labels.
- C. Fiber Optic Cables:
  - 1. Confirm labeling scheme with owner.
  - 2. Locate label in a visible and readable location.
  - 3. Label Information: The cable identifier is the cable number followed by the cable pair/strand count (numeric characters), both the beginning and ending count.
  - 4. Provide polyethylene non-conductive cable tags with cable numbers. Provide "Mini-Tags" similar to model number SH as manufactured by Almetek Industries, Inc. The mini-tag holder shall be of sufficient length that the complete number is held in one holder with all information on one line.
- D. Cables, General: Label each cable within 4-12 inches of each termination, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
  - 1. Any discrepancy or dispute of building, room and/or location labeling shall be brought to the owner's attention for immediate resolution.
- E. Inside Plant Fiber Optic Cables:
  - 1. Label Location: On the jacket or sheath of the cable at both ends (before the fan-out or breakout point) and at every splice. Place the label near the cable entrance into the termination hardware and exterior to the termination hardware. Label shall be located in a visible and readable location.
  - 2. Label Information: Building Number, TR number, fiber count, type and installation date.
  - 3. Method: Brady label, part number WML-1223-292, or approved equal.
  - 4. Example: Science Bldg MTR to Data Center, 1-12 mm, 10/20/2012
- F. Fiber Termination Enclosure Frames:
  - 1. Label Location: On the outside of the enclosure surface in the top left corner of the panel front.
  - 2. Label Information: Near end cabinet number and panel number and fiber type as well as the FAR END cabinet number and panel number.
  - 3. Example method: Machine printed Brady labels, part number PSL-1833-619-BK, or approved equal.
  - 4. Example: Cabinet 1, panel 2, SM to Data Center Cabinet 1 panel 2.
- G. Building Fiber Terminations within the Fiber Termination Enclosure Frames:
  - Label Location: On the inside front panel of the enclosure in the location identified by the manufacturer for the label. In most cases, the manufacturer's label will be used and re-labeled. The connector layout within each closure may vary. In general, the columns of fiber connectors are grouped in units of six to twelve connectors. Columns count from left to right. Termination positions

within a column count from top to bottom. Refer fiber termination numbering conflicts to the Owner for a decision.

- Label Information: Total fiber terminations within enclosure, 1- 48 maximum. The label for each panel and connector should indicate the FAR END termination location. Anyone can see what is the near end location. What is required is the FAR END location.
  - a. Labeled as follows: A1, A2, A3, etc. according to where the FAR END is terminated.
- 3. Method: Machine printed Brady labels, part number CL-111-619, or equivalent.
- H. TR/MTR:
  - 1. Label Location: On wall, 12 inches below cabling tray.
  - 2. Label Information: Building Number, TR number, fiber count, type and installation date.
  - 3. Method: Adhesive label, 3 inches high with safety orange background and black lettering.
  - 4. Example manufacturer: 3M P/N: Scotchlite 5025 reflective lettering system or approved equal.
- I. Cable Administration Drawings:
  - 1. Show building floor plans with cable administration point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions.
  - Follow convention of TIA/EIA-606. Furnish electronic record of all drawings, in software and format selected by Owner. Each fiber strand terminated in patch panel or workstation outlet and each cable entering termination points shall be labeled with unique identifying code.

END OF SECTION

## SECTION 27 1510 – HORIZONTAL COPPER CABLE AND EQUIPMENT

#### PART 1 - GENERAL

- 1.01 SCOPE OF WORK
  - A. Base Bid:
    - 1. Contractor provide:
      - a. Horizontal unshielded twisted pair (UTP) station cable consisting of Category 6 cable to function as a universal structured cabling system for both voice and data.
      - b. Cable terminations in patch panels and station jacks
      - c. Testing, labeling and manufacturer's certification (performance warranty)
      - d. Accurate as-built jack plans in AutoCAD format indicating actual field labels at each location.

## 1.02 SECTION INCLUDES

- A. Unshielded Twisted Pair Cable
- B. Miscellaneous Cable
- C. Modular Jacks and Faceplates
- D. Voice Patch Field
- E. Data Patch Field
- F. Coax and Connectors
- G. Splicing
- H. Cable Support
- I. Testing Requirements
- J. Labeling Requirements

#### 1.03 RELATED WORK

- A. Section 27 05 00 Common Work Results for Communications Systems
- B. All references including Division 26 apply

#### 1.04 SUBMITTALS

- A. Submit shop drawings for equipment under this section per section 01 30 00 Administrative Requirements.
  - 1. Unshielded Twisted Pair Cable
  - 2. Miscellaneous Cable
  - 3. Modular Jacks and Faceplates
  - 4. Voice Patch Field
  - 5. Data Patch Field
  - 6. Coax and Connectors
  - 7. Splicing
  - 8. Cable Support
  - 9. Testing Equipment
  - 10. Labels
- B. Submittals should be grouped to include complete documentation of related systems, products and accessories in a single submittal. If provided electronically in PDF format, one specification section should equal one file or file name. Do not scan multiple specification sections into one file.
- C. Where applicable, dimensions shall be marked in units to match those specified.

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- D. Submittals shall be original catalog sheets or photocopies thereof. Facsimile (fax) sheets or printed web pages shall not be accepted. Circle appropriate part number with black pen. Circle appropriate picture if more than one appears on page. Do not use highlighter which cannot be reproduced on a copy machine.
- E. Contractor shall indicate on submittal the system(s) served by each cable submitted.
- F. Submit manufacturer's installation instructions.
- G. For testing equipment, submit current year's calibration certificate.
- H. Project Record Documents: Record on plans actual locations of components and information outlets with their associated faceplate labels.
- I. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
- J. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- K. Work shall not proceed without Engineer's approval of submitted items.

## 1.05 PERFORMANCE TESTING

- A. The following equipment shall be performance tested
  - 1. Unshielded Twisted Pair Cable
    - a. Per ANSI/TIA-568-C.2
  - 2. Miscellaneous Cable
    - a. Per manufacturer recommendations or continuity test at a minimum
  - 3. Modular Jacks and Faceplates
    - a. Per ANSI/TIA-568-C.2
  - 4. Voice Patch Field
    - a. Continuity
    - Data Patch Field
    - a. Per ANSI/TIA-568-C.2
  - 6. Coax and Connectors
    - a. Continuity and sweep test
  - 7. Splicing

5.

- a. Continuity
- 8. Cable Support
  - a. Visual inspection, j-hook supports every 48"
- 9. Testing
  - a. Equipment to be calibrated yearly (provide certificate)
  - b. Cables to be tested as described in Part 3 Execution
- 10. Labeling
  - a. Visual inspection to confirm that all faceplates are labeled per Part 3 Execution or per owner/engineer approved method.

## PART 2 – PRODUCTS

#### 2.01 UNSHIELDED TWISTED PAIR CABLING

- A. General:
  - 1. Cabling shall:
    - a. Be constructed of individually twisted pairs.
    - b. Be suitable for installation in environment defined.
    - c. Be packaged to minimize tangling and kinking of cable during installation.

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  - 2. Pair twists of any pair shall not be the same as any other pair.
  - 3. Pair twist lengths shall be selected by manufacturer to ensure compliance with near-end crosstalk (NEXT) requirements of ANSI/TIA 568-C.2.
  - 4. Four pair, 23 AWG, with a bisector tape that delivers the performance needed for the unshielded twisted pair. solid copper cables.
  - Number of pairs per sheath: 4 5.
  - UL Listing: Non-plenum (CMR). 6.
  - Color Coding: 7.
    - White-Blue a.
    - b. White-Orange
    - White-Green C.
    - White-Brown d.
  - Conductor Resistance: 7.61W per 100/Meter at 68° (maximum) 8.
  - Characteristic Impedance: 100W +/- 15% @ 1 to 100 Meters 9.
  - 10. Maximum Attenuation: 2.0 dB/Meter @ 1.0 MHz or 5.0% above TIA 568 15.6 dB/Meter @ 62.5 MHz
  - 11. Capacitance: 5.6 nF/100m at 1kHz
  - 12. Near End Crosstalk: 71 dB @ 1.0 MHz or 6dB above TIA 568 49.4 dB @ 62.5 MHz
  - Station Data Cable: Β.
    - 1. Manufacturers:
      - a. Uniprise, part no. UN874049914/10
      - b. Svstimax
      - C. Siemon
    - 2. Cable shall:
      - Be a single vendor end to end solution with better than minimally compliant performance a. ratings.
      - Be non- plenum rated. b.
      - Shall be used for both voice and data applications. C.
      - Blue color sheath d.
      - Category 6, capable of 1 Gig transmission and utilizing 802.3AT Power over Ethernet e. (PoE+) at 25 Watts
      - f. Exceed ANSI/TIA 568-C.2 performance specifications for Category 6 by average of 2dB.
      - Better than minimally compliant Category 6. g.
      - Product literature indicating testing to 250-350 MHz h.

#### 2.02 MISCELLANEOUS CABLING

- Speaker/sound system, security and audio-visual cable see applicable specifications (if required). Α.
- Β. 16/2 insulated stranded copper speaker wire.

#### 2.03 MODULAR JACKS AND FACEPLATES

- General: Α.
  - 1. Manufacturers: To match brand of station data cable
  - 2. Voice and data jacks shall snap into mounting frame, which shall mount into faceplate.
  - Jacks and connectors may be mounted directly into faceplate. 3.
- Faceplates: Β.
  - Faceplates shall: 1.
    - Be constructed of high impact plastic (except where noted otherwise). a.
    - Color shall be white. Confirm final color of faceplate with engineer or architect prior to b. ordering and installation.

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- Be configured to mount on standard, single gang outlet box when wall mounted. C. Exception: Conference/meeting room projector outlets to be double gang faceplates 1)
- Incorporate recessed designation strips at top and bottom of frame for identifying labels. d.
- Triple row faceplates with no provisions for labeling of middle outlet row are not е acceptable.
- f. Designation strips shall be fitted with clear plastic covers.
- Accommodate minimum of 4 modular jacks and connectors. α.
- Faceplates for wall mounted voice-only outlets (wall-phones) shall accommodate wall-mounted 2. telephone sets.
  - a. Faceplate shall be stainless steel construction, accommodate 1 voice jack, mount on standard single gang outlet box and include mating lugs for wall phone mounting.
- All device plates in Mechanical Rooms shall be brushed stainless steel with proper openings for 3. the wiring device.
- C. Data Jack:
  - 1. Data Jacks shall:
    - Meet the following specifications: a.
    - b. Manufacturer:
      - Uniprise, part no. CC0020917/1 1)
      - 2) Systimax
      - 3) Siemon
      - 4) Category: 6
      - 5) Shall be "tuned" to match data cable in every respect as a "certified" system.
      - 6) Be of same brand as selected cable unless prior engineer approval is obtained.
    - Be non-keyed, 8-pin Modular Jack (8P8C). C.
    - Be pinned per 568B with pair as follows: d.
      - Pair 1 Pins 5 & 4 1)
      - 2) Pair 2 - Pins 1 & 2
      - 3) Pair 3 Pins 3 & 6
      - 4) Pair 4 - Pins 7 & 8
    - Be orange in color or shall match faceplate color. Since all universal cable may be used e. for any purpose, there is no need to color code jacks according to application.
  - 2. Interface between jack and station cable shall be insulation displacement type contact. Termination components shall be designed to maintain cable's pair twists as closely as possible to point of mechanical termination.
  - 3. Jack contacts shall have minimum of 50 micro-inches of gold plating.

#### 2.04 **VOICE PATCH FIELDS**

- Α. General:
  - Cross connect blocks shall: 1.
    - Be designed to maintain cable pair twists as closely as possible to point of mechanical a. termination.
    - b. Identify pair position by color designation.
      - Colors shall be Blue, Orange, Green and Brown for Station Cables and Blue, Orange, 1) Green, Brown and Slate for Backbone Voice Cables.
  - 2. Each horizontal row of cross connect blocks shall be capable of terminating one 25 pair binder group of Backbone Voice Cable, or six 4 pair Station Voice Cables.
- Backbone Voice Cable and Station Voice Cable Blocks: Β.
  - 1. Manufacturers: To match brand of station data cable
  - Blocks shall be wall mounted 110-style cross-connect blocks. 2.

# 3. Termination equipment shall meet full Category 5e performance criteria (even though cable is Cat 6 – blocks are only for voice circuits).

- 4. Mechanical termination on cross connect bocks shall:
  - a. Have ability to terminate 22-26 AWG plastic insulated, solid and stranded copper conductors.
  - b. Provide direct connection between station or backbone cable and jumper wires.
  - c. Have less than 0.2dbB attenuation.
  - d. Have less than 100 m ohms of DC resistance.
  - e. Have less than 5 m ohms of resistance imbalance.
  - f. Have minimal signal impairments at all frequencies up to 250 MHz.
- 5. Blocks must utilize a transition technology from 110 style (to backbone cable) to RJ-45 style to horizontal cable. Intent is for owner to be able to use only RJ-45 (8P8C) patch cords for both voice and data patching. 110 blocks may be tied to an auxiliary block for RJ-45 transition using either integrated circuit board connections on the same block, or using a remote block with amphenol connectors.

## 2.05 DATA PATCH FIELDS

- A. Data Patch Panels:
  - 1. Manufacturers: To match brand of station data cable and data jacks (see above)
  - 2. Panels shall:
    - a. Be rack mountable in standard TIA 84"H x 19"W equipment racks.
    - b. Match cable and jack type, compatible with Cat 6 "certified system".
    - c. Consist of modular 110-type connector system or blank panels able to accept snap-in jacks.
    - d. Have ability to seat and cut 8 conductors (4 pairs) at a time.
    - e. Have ability of terminating 22-26 AWG plastic insulated, solid and stranded copper conductors.
    - f. Be designed to maintain cable's pair twists as closely as possible to point of mechanical termination.
    - g. Have cable support and strain relief devices to secure cables at 110-type termination blocks.
    - h. Insure minimum bend radius requirements are satisfied.
    - i. Have color-coded designation strips to identify cable types and ID numbers.
    - j. Be flat or angled to permit direct access to vertical cable managers.
    - k. Permit individual cable or jack labeling.
    - I. Provide sufficient patch panel ports for current project plus 25% spare, unused ports for future use by owner.

#### 2.06 COAX AND CONNECTORS

- A. Station Coaxial Cable shall be RG-6 type
  - 1. Manufacturers: CommScope, Belden or match brand of station data cable
  - 2. Construction (RG-6 type, quad-shield):
    - a. Center Conductor: 18 AWG copper-clad steel (0.040" nominal outer diameter).
    - b. Dielectric: Gas expanded (foamed) polyethylene (0.180" nominal diameter).
    - c. First shield: Aluminum-polypropylene-aluminum laminated tape with overlap bonded to dielectric.
    - d. Second shield: 34 AWG aluminum braid wire (60% coverage).
    - e. Third shield: Non-bonded foil shield.
    - f. Fourth shield: 34 AWG aluminum braid wire (60% coverage).

# g. Jacket: Flame retardant PVC (0.300" nominal outer diameter). Jacket shall contain carbon black to ensure ultraviolet light stability (UV).

- h. Capable of passing frequencies up to 3 GHz.
- 3. Specifications:
  - a. Impedance:  $75 \pm 3$  ohms
  - b. Velocity of Propagation: 87% nominal
  - c. Maximum Attenuation @ 68°F: 1.60 dB/100 ft. (55 MHz)
  - d. 5.65 dB/100 ft. (750 MHz)
  - e. Cable Rating: Type CATVR , riser rated
  - f. Flame retardant PVC outer jacket, non-plenum rated
  - g. Capable of passing frequencies up to 3 GHz.
- 4. Coax Connectors
  - a. Coaxial Connectors shall be threaded male F-type.
  - b. Male F-connectors shall:
  - c. Be matched to the RG-6 cable type used
  - d. Be a single piece connector
  - e. Incorporate a 1/2" crimp ring using hex crimp
  - f. Use female/female feed-through couplings for coaxial outlets and patch panels.
- B. Backbone RG11 Coaxial Cable shall be RG-11 type
  - a. Center Conductor: 14 AWG copper-clad steel
  - b. Dielectric: Gas expanded (foamed) polyethylene
  - c. Quad Shield,
    - 1) Inner shield (braid) coverage 60%, 36AWG braid, tinned copper
    - 2) Inner shield (tape) aluminum/poly
    - 3) Outer shield (braid) coverage 50%, 36 AWG, tinned copper
    - 4) Outer shield (tape) aluminum/poly
  - d. Jacket: Flame retardant PVC (0.300" nominal outer diameter). Jacket shall contain carbon black to ensure ultraviolet light stability (UV).
  - 2. Specifications:
    - a. Impedance:  $75 \pm 3$  ohms
    - b. Velocity of Propagation: 86% nominal
    - c. Conductor DC resistence:11 ohms/1000ft
    - d. Structural return loss: 15 dB @ 1000-3000MHz, 20 dB @ 5-1000MHz
    - e. Cable Rating: Type CATVR
    - f. Flame retardant PVC non-plenum outer jacket.
  - 3. Coax Connectors
    - a. Coaxial Connectors shall be threaded male F-type.
    - b. Male F-connectors shall:
    - c. Be matched to the RG-6 cable type used
    - d. Be a single piece connector
    - e. Incorporate a 1/2" crimp ring using hex crimp
    - f. Use female/female feed-through couplings for coaxial outlets and patch panels.
- C. PASSIVE DEVICES (SPLITTERS AND TAPS)
  - 1. General
    - a. NOTE: In some locales, the contractor only coils the cable at the intermediate termination point, leaving the final tap, splitter or amplifier equipment for the cable TV service provider. GC and LV contractors shall confirm this approach prior to bidding, pricing and installation to clarify scope.

- b. Manufacturers: Blonder Tongue, Regal, Phoenix Communications Technologies (PCT.), Channel Commercial Corp., PicoMacom, Channel Vision, PDI.
- c. Impedance: 75 Ohms.
- d. Bandwidth: 5 MHz 1000 MHz.
- e. Port type F female.
- f. Where more than one connector exits from common surface of device, connectors shall be spaced minimum of 0.925" apart, center-to-center.
- g. Indoor-rated devices may not be equipped with grounding wire attachment points.
- h. Outdoor-rated units shall be equipped with grounding wire attachment points.
- i. Each port of device shall be labeled. Designations shall be in accordance with following:
- j. Common port shall be labeled as "common", "in", or "input".
- k. Directional couplers/taps port receiving greatest percentage of input signal shall be labeled "thru", "through", "out" or "output".
- I. If nominal loss is in excess of 1 dB, port shall also indicate nominal loss from input to output.
- m. Port(s) receiving lower percentage of input signal shall be labeled "tap:
- n. Shall be labeled with nominal loss from input in form "-N dB" where "n" is nominal loss.
- o. Splitter output ports shall be labeled "out" or "output" and shall include port number.
- p. Ports shall also indicate nominal loss from input to port in form "-n dB" where "n" is nominal loss.
- q. Labels shall indicate port function and signal loss.
- r. Components which do not meet environmental requirements (salt spray, corrosion resistant and rated from -40°F to +140°F) shall be permanently labeled "For indoor use only".
- s. Capable of passing frequencies up to 3 GHz.
- 2. Splitters:
  - a. Splitters shall:
  - b. Be available in 2, 3, 4, 6 and 8 port options.
  - c. Specifications:
- 2.07 SPLICING
  - A. Splices are not allowed unless indicated on project documents.

#### 2.08 CABLE SUPPORT

- A. J-Hooks
  - 1. Wide-base design with smooth, beveled edges providing a large bending radius for all J-Hook sizes.
  - 2. Meets ISO/IEC 18010, TIA-569-B and is used for large-diameter cable, including Cat. 6A
  - 3. Accommodates a variety of attachment methods threaded rod, wall mount, etc. and is expandable for additional integrated pathways
  - 4. Easily attaches to other fasteners in multiple configurations: J-Hook- to- J-Hook or J-Hook to fasteners
  - 5. Requires no screws, rivets or special tools for installation of fastener assemblies, tree bracket assemblies or puller assemblies.
- B. "Arlington" Loop or Saddle Cable Hangers
  - 1. Provides sturdy reliable support of Category 5, 6 or fiber optic cable without sagging, bending or damaging the cable
  - 2. UL/CSA Listed for Environmental Handling Spaces
  - 3. Flexible and non-metallic

#### HORIZONTAL COPPER CABLE AND EQUIPMENT 27 1510 - 8 10/24/2019

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- 4. Single or multiple LOOP hangars mount in a variety of ways and rotate to any angle
- 5. Sizes/Cable Holding Capacity 2" holds a 2" cable bundle, 2.5" holds a 2.5" cable bundle, and 5" holds a 5" cable bundle
- 6. Available with or without UV rating
- C. Bridle Rings
  - 1. Bridle rings (made of round stock) by themselves are not acceptable
  - 2. Bridle rings may be acceptable if used in conjunction with wide-surface plastic saddle inserts

## 2.09 TESTING EQUIPMENT

A. Hand-Held Portable Tester

- 1. Level III field tester for Category 6 class E cabling for up to 250 MHz
- 2. Level IV field tester for Category 6A class EA cabling up to 500 MHz
- 3. Factory calibrated yearly (certificate for current year must be provided)
- 4. Capable of printing individual cable test results in text and graphical formats
- 5. Capable of printing one sheet per test or roll up of many tests on one sheet indicating simple PASS or FAIL result
- 6. Capable of converting files to PDF format
- 7. Tester interface adapters must be of high quality and be capable of using the installed connectivity manufacturer's patch cables for performing permanent link certification testing.
- 8. Capable of Auto-Testing from either the display unit or the remote unit to decrease testing time

## 2.10 LABELING

A. See section 27 05 53

## PART 3 – EXECUTION

## 3.01 CABLE INSTALLATION REQUIREMENTS

#### A. Station Data Cable

- 1. Provide Station Data Cable from SIOs to TRs.
- 2. Terminate Station Data Cables in rack mounted Data Patch Panels.
- 3. Station Data Cables shall be home run to TRs from SIO locations.
- 4. Cables shall have pair twists preserved to point of termination
- 5. Cable jacket shall be continuous to within 1/2" of termination or as recommended by certified system.
- 6. Terminate cables using 568B wiring standard.
- 7. Terminate Cable pairs in TRs and at SIOs.
- 8. Maximum station cable length shall not exceed 295 ft. (90 meters) measured from termination block in TRs to SIO, including slack required for installation and termination. Contractor is responsible for installing station cable to avoid unnecessarily long runs.
- 9. Any area that cannot be reached within above constraints shall be identified and reported to Engineer immediately. Installation shall not proceed for cables beyond prescribed distance limitations. Notify engineer of any cables that will be between 270 and 295 feet long.
- 10. Provide data cable to every security camera location noted on prints
  - a. Contractor to coordinate camera locations with camera vendor. Security camera vendor is responsible to indicate to data cabling contractor precise location for each camera data outlet. Typically, camera data jacks are to be located above ceiling tile near camera locations.
- B. Cable Routing
  - 1. Cabling shall be run in raceways provided, or as designated on floor plans.

- 2. Cable shall be free of tension at both ends. In cases where cable must bear stress, provide Kellem grips to spread stress over longer length of cable.
- 3. Make every effort to run cables in TRs and riser shafts neatly, straight, well dressed, labeled on every floor and organized according to type or function.
- 4. Where station cables must pass between floors (because no TR exists on same floor), gently contain cable bundle within loop of Velcro straps and label cable bundle with TR destination including floor number and TR room number.
- 5. To reduce effects of EMI, the following minimum distances shall be adhered to:
  - a. 5" from power lines of 2kVA
  - b. 18" from high voltage lighting (including fluorescent)
  - c. 39" from power lines of 5kVA or greater
  - d. 39" from transformers and motors

## 3.02 MISCELLANEOUS CABLE

A. Provide and install cable as recommended by manufacturer

## 3.03 MODULAR JACKS AND FACEPLATES

- A. Provide one faceplate per communications outlet symbol (faceplate) shown on Project Documents.
- B. Provide data jack(s) in faceplates as shown on Project Documents.
- C. Terminate all pairs of Data Station Cable in their respective jacks.
- D. Mount jacks into faceplates and secure faceplates to outlet box or modular furniture.

## 3.04 VOICE PATCH FIELDS

- A. General:
  - 1. At TRs, terminate Backbone Voice Cables and Station Voice Cables on backbone and station cross-connect blocks.
  - 2. Provide horizontal troughs incorporating distribution rings to accommodate jumper routing.
  - 3. Position troughs at top and/or bottom of each cross-connect block and between each column of blocks.
  - 4. Cabling entering and exiting fields shall be neatly laced, dressed and supported.
  - 5. Provide tie cables and auxiliary punch blocks near horizontal cable patch panels for easy patching between horizontal cable and riser cable.
  - 6. Intent is to permit owner to use only RJ-45 patch cables for both voice and data patching from rack to wall field.
  - 7. Auxiliary voice patch blocks need only connect center two pins for tip and ring function to backbone cable.

## 3.05 DATA PATCH FIELDS

- A. Data Patch Panels:
  - 1. Provide patch panels as shown on the Project Documents.
  - 2. Mount patch panels in 19" equipment racks or wall mount brackets.
  - 3. Provide minimum of four (4) screws to secure each patch panel onto rack.

#### 3.06 COAX AND CONNECTORS

- A. Provide backbone cable as indicated on project documents.
- B. Provide horizontal cable as indicated on project documents.
  - 1. Provide one horizontal cable from every outlet indicated on plans back to intermediate termination point or telecom room. DO NOT use splitters within resident rooms or any location other than an intermediate termination where plywood and power is available.

PERMIT SET

- 2. In some locales, the contractor only coils the cable at the intermediate termination point, leaving the final tap, splitter or amplifier equipment for the cable TV service provider. GC and LV contractors shall confirm this approach prior to bidding, pricing and installation to clarify scope.
- C. Provide appropriate connectors on each cable end.
- D. Terminate TR end of cable with appropriate connector, tap or splitter.
- E. Coordinate final termination type and location in main TR with local cable service provider. In some cases they may have specific requirements.

## 3.07 SPLICING

A. If required, provide splicing as indicated on project documents

## 3.08 CABLE SUPPORT

- A. Provide J-Hooks or other approved cable supporting device for cable where cable tray and conduit are not available.
  - 1. Support cable support devices by means of threaded rod and/or beam clamps suspended from building structure or from building structures themselves such as trusses, joists, rafters, beams, columns and walls.
  - 2. If walls are used, devices must be attached only where wall studs serve as support. Supporting screws must penetrate into studs.
  - 3. Cable supporting devices must be supported on four (4) foot centers, plus or minus one (1) foot.
  - 4. Do not utilize supports for other systems (such as drop ceiling wire) without prior approval of engineer or construction manager.

## 3.09 CABLE TESTING

- A. Hand Held Tester
  - 1. Calibrate field tester each day as required by manufacturer.
  - 2. Adjust NVP (nominal velocity of propagation) values, temperature, cable brand, etc. specific to the cable brand being installed.
  - 3. Test each cable per ANSI/TIA-568-C.2 standards.
  - 4. Save each test result and label results to match actual field labels.
  - 5. Print test results or provide in electronic (PDF) format.
- B. Station Data Cable
  - 1. Test each installed link to 250 MHz as required by ANSI/TIA-568-C.2 for compliance with specified performance characteristics utilizing a Level III tester or as required by manufacturer to obtain system warranty and as required by ANSI/TIA-568-C.2 Category 6 requirements.
  - 2. Each pair of each horizontal cable shall be verified for wire map (transposed/reversed/split pairs) and shorts through toning of each conductor.
  - 3. Maximum length of station cable shall not exceed 90 meters.
  - 4. Worst case performance, based on maximum length of 90 meters, shall meet ANSI/TIA-568-C.2 standards.
  - 5. Tests made and documentation provided shall consist of wire map, Power-Sum near-end crosstalk, Power-Sum equal level far-end cross talk, return loss, attenuation, cable length and resistance using TDR technology.
  - 6. Test results shall meet or exceed cable manufacturer's requirements for Cat 6 certified system Any cable that does not meet manufacturer's requirements for a certified system shall be retested or replaced at contractor expense until cable meets the requirements.
  - 7. Submit Test Results for each Horizontal Link in electronic form a) in the native format of the test instrument and b) summarized in a fashion that includes a graphical display of all test parameters in PDF form.

- PERMIT SET
  - 8. The summary shall document the worst-case margin over minimal TIA "Category" compliance for the cables tested. The summary shall be in Adobe Acrobat PDF format.
  - C. Coaxial Cable:
    - 1. Test each cable for end-to-end continuity using tone generator or other testing device.
    - 2. Use Time Domain Reflectometer (TDR) to verify cable length and to test for cable faults and breaks.
    - 3. Use step-function high resolution Time Domain Reflectometer, such as Tektronix 1502C or Hewlett-Packard 1415A.
    - 4. Results shall be automatically plotted on X-Y plotter with Y axis voltage reflection coefficient resolution of .001 per division. X axis shall resolve down to 1" of cable.
    - 5. TDR will sweep cable at rate no greater than 50 ft. per second, or such lower rate as necessary to resolve cable faults to the 1" and .001 VRC level.
    - 6. After connection to Cable TV service, test each coax (television) outlet for signal strength.
    - 7. Each coax outlet shall test to +3dB to +10dB.
    - 8. Hook up room TVs or use temporary, portable TV to visually test and inspect channel reception and picture quality at every location. Picture quality shall be acceptable to owner/engineer. Provide notification to owner 24hrs in advance of visual inspection test.

## 3.10 LABEL IDENTIFICATION

- A. Station Cable
  - 1. Refer to section 27 05 53
  - 2. Label each SIO faceplate and each cable entering SIO and TRs with unique identifying code.
  - 3. Label cable with tag, which is wrapped around cable sheath
  - 4. Place faceplate labels on outside of cover
  - 5. Place data and voice punch down block labels above or below the termination
  - 6. Labeling shall be by mechanical means in black ink on non-removable tags
  - 7. Hand lettered designations are not allowed
  - 8. Station Cabling labeling code shall be as follows:
    - a. A-B-CCC where:
      - 1) A = Room number of TR where cable terminates
      - 2) B = Floor Number (optional if room number already gives floor indication). Begin with floor on which jack is terminated
      - 3) CCC = Jack number in sequential order on that floor, e.g. 001, 002, 003, etc. Start number sequence over on every floor
      - 4) Example: Jack number 101 on floor 3 terminates in TR 318: 318 -101 (no need for separate floor designation in this case).
  - 9. Faceplate labels can use common room number designations on each label strip. For example, two data jacks served from TR 318 sharing a common label strip could be represented by:

	-	<u> </u>	_
Т	R3	818	
101		102	

- 10. Label all patch panels in TRs with identical label as used on jacks
- 11. Labels on as-built documentation and test results to match field labels
- 12. Prior to installing labels, consult with owner to verify labeling scheme

END OF SECTION

## SECTION 27 5113 – OVERHEAD SPEAKER/SOUND SYSTEM

### PART 1 – GENERAL

- 1.01. WORK INCLUDES
  - A. Base Bid:
    - 1. Contractor provide:
      - a. Complete, functioning audio system for distribution of multiple audio sources to multiple locations.
      - b. Amplification and distribution equipment to obtain dual source input from head end or telephone system to distribute to multiple zones or locations.
      - c. Ceiling, wall and outside rated horn speakers as indicated on project documents.

#### 1.02RELATED WORK

- A. Specified Elsewhere:
  - 1. 27 01 00 Communication Systems
  - 2. All references including Division 26 apply.

## 1.03REFERENCE

- A. The Work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.
- 1.04 SUBMITTALS
  - A. Submit shop drawings for equipment provided under this Section per requirements in Section 27 01 00. Shop drawings shall include:
    - 1. Outline drawings of equipment showing overall dimensions, power, control and signal wiring.
    - 2. Termination drawings and one-line Paging System riser drawings showing all equipment and room numbers.
    - 3. Literature describing in detail equipment proposed and all operating modes.
    - 4. Complete review of this specification, noting for each paragraph whether or not proposed equipment complies with project specifications or deviates in some fashion. Include justification for each deviation proposed.

#### 1.05 FCC COMPLIANCE

A. Equipment furnished under this contract shall have been tested and made to comply with limits for Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environment. Literature shall so note and equipment shall be so labeled to show this compliance.

#### 1.06 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Contractor shall furnish to Engineer, upon completion of work, but before final acceptance of system, 3 bound typewritten copies of instructions covering complete maintenance and operation of system and complete set of as-built drawings. Contractor shall instruct owner on care, operation, and maintenance of all parts of system.
- B. In addition to complying with Div 26 General Electrical Requirements, Contractor shall provide 3 sets of complete instruction manuals, service manuals, schematics, parts lists, recommended spare parts lists, and current list of local manufacturer approved service centers.
- 1.07 OWNER TRAINING
  - A. Page System supplier shall provide training (1 hours minimum) for Owner's personnel on operation and maintenance of page system. Training shall be complete to enable personnel to perform associated tasks and

functions in competent and skillful manner. Training shall be conducted during normal business hours after system start-up and Owner acceptance.

#### 1.08GUARANTEE

- A. Overhead Speaker/Sound System (known as "System") and components shall be guaranteed free from defects in workmanship and materials for a period of 1 year from date of acceptance by Owner. During guarantee period, manufacturer shall perform services necessary on the System, and supplier shall provide annual inspections, written reports to Owner detailing findings of each inspection, and documentation of action(s) taken to remedy abnormal conditions.
- 1.09 DESCRIPTION
  - A. Provide materials and labor for a complete Overhead Speaker/Sound System which will provide live input to loudspeakers in selected portions of building complex. System shall include loudspeakers, grilles, horns, volume controls, wiring and associated equipment and hardware to provide complete working system. Components shall be UL listed for their function and installation, except as otherwise noted.
  - B. Transmit live voice to overhead speakers in various offices and public areas as indicated on drawings.
  - C. Speakers, horns, cable to the speakers and volume control, zone controller and telephone/page interface by this contractor.
  - D. Coordinate with owner for connection to existing audio distribution equipment or phone system.
  - E. Provide complete design, layout and functioning system per manufacturer's recommendations.

## PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

A. Valcom 24 volt

## 2.02PAGE CONTROL, POWER SUPPLIES

- A. Provide equipment as noted on project documents. Audio source provided by owner.
- B. Power supply as required by Valcom design

## 2.03SPEAKERS AND GRILLES

- A. 8" round standard ceiling speaker for ACT or GYP mounting
- B. Wall mount, rectangular, to fit in wall cavity between studs where required in dining room
- C. Surface mount where required
- D. Outside rated horns where noted
- E. One-way, single-cone
- F. Internal amplifier per Valcom specs

#### 2.04FACEPLATES, VOLUME CONTROL

- A. Stainless Steel, single-gang, white color also acceptable
- B. Dial type volume control knob (potentiometer or attenuator) with volume markers

#### 2.05MIXER/DIGITAL SIGNAL PROCESSOR

A. Provide equipment (if required) to accept inputs from owner-provided equipment to interface between owner source and paging amplifier.

B. Amplifier may have sufficient input without need of mixer.

C. System shall accept one (1) 3.5mm or mini-phono line level input to be distributed to all zones simultaneously.

## 2.06CABLE

- A. Speaker cable as recommended from head-end to volume controls or speakers
- B. Use of Category 6 data cable similar to rest of project is recommended.

## 2.07 POWER AMPLIFIER / ZONE CONTROLLER

- A. As recommended or required by manufacturer
  - 1. Valcom speakers typical have internal amplifier provide required power supply
  - 2. Provide one (1) line-level 3.5 mm or mini-phono input or provide mixer/DSP as required to interface between owner-provided source and amplifier. Only one music source input is required.

## 2.08FIRE RATED COVER

- A. Similar to Tenmat 1 or 2 hour speaker cover
  - 1. Use where fire rating of ceiling or wall must be maintained
  - 2. www.tenmatusa.com

## 2.09 CABLE MANAGEMENT RACEWAY

- A. Plastic or metallic type with fingers
- B. Small innerduct or "smurf tube", spiral wrap and cable ties as required
- C. J-hooks or cable try in ceilings

## PART 3 - EXECUTION

#### 3.01 GENERAL

A. Provide speakers and volume controls at locations noted on drawings.

## 3.02 INSTALLATION

- B. Install system in accordance with manufacturer's recommendations. System wiring shall be riser rated conductors as approved by local codes and installation practices. Wiring shall be placed in communications cable trays or supported from building members using j-hooks, threaded bridle rings, or equal assemblies).
- C. Provide amplification devices sufficient to power all speakers with an additional capacity of 50%.
- D. Connect speaker wire from volume control in each room using appropriate tap value usually 1-5 Watt tap or as required by amplifier capacity and number of speakers.
- E. Amplifier main volume control and other outputs to be adjusted at 12:00 noon position to provide required dB SPL at speaker locations.
- F. System shall provide 75-85dB SPL at 72" AFF. Adjust tap value at each speaker accordingly to allow main volume control to remain at 12:00 position.
- G. Verify sound level at each location with owner/operator and adjust as required.
- H. Cables shall be continuous from first (closest) speaker to telecom room and free of splices.
- I. Provide zone controller to permit one zone per floor. Programming shall permit separate zones as well as one zone for all-call capability.

- J. Provide wall mounted volume controller for each zone.
- K. Coordinate with voice PBX or VoIP phone system for access to port to permit page control from telephone system (handsets) by means of 3-4 digit access code.
- L. Speakers on same floor may be daisy-chained per manufacturer's instructions. Daisy chain splices shall be made only in accessible locations at or near ceiling speakers or within volume control back box. Do not splice cables mid-run at locations other than at speakers or within back boxes. All splices and terminations must remain accessible.
- M. Refer to project documents for cable riser and connection diagram.
- N. Cables installed in exposed areas, i.e., mechanical rooms, shall be enclosed in conduit.
- O. Final connections and equalizing of systems shall be made by experienced personnel.
- P. Provide hinged cover wiring duct on telecom room wall to manage cables from floor and ceiling to amplifier location.
- Q. Provide all cables as indicated on project documents and as recommended by manufacturer. The fact that certain cables may not appear on project documents does not relieve contractor of the responsibility to provide all required cables and connections for a fully functioning system.
- R. Provide speakers where indicated on drawings. Coordinate with other utilities. Speaker locations may be relocated slightly to accommodate other utilities.
- S. Coordinate speaker location with other utilities and services in ceiling space and ceiling tiles.
- T. Speakers should be located near center of room, center of hallway or towards desk locations if in offices or conference rooms.
- U. Provide faceplates with volume control where (if) required.
- V. Provide flush, in-wall speakers in areas where ceiling is not available for ceiling speakers.
- W. Provide desk mount speakers where neither ceiling nor walls are available for speaker mounting. Every attempt has been made to indicate locations on project documents where desk mounted speakers are required. When in doubt, consult with owner.
- X. Refer to project documents for connection diagrams.
- Y. Coordinate with owner for access to Ethernet, telephone or AV network.

#### 3.03 LABELING

- A. ALL Cables in telecom room shall be LABELED indicating floor of destination and location of zone. Label cables according to room number of first office or hallway in line to be connected. Also label as to which TR cable is home run. Labels shall be permanently affixed to cable sheath approximately 12" from end termination at amplifier. Labels may have to be replaced or relocated to comply with this requirement after amplifier is installed.
- B. Provide cable label on cable sheath 12" from first office ceiling speaker or where cable enters conduit down to volume control. Label to indicate head-end location (telecom room number and floor) as well as indication of "HEAD-END" to indicate cable run is first in line. If volume controls are not required, provide label near speaker location in ceiling.
- C. At every successive ceiling speaker, provide label indicating office number of next office in line away from and towards head end. Each label shall indicate the "to" and "from" location for the next office or hallway in line.
- D. Example:
  - 1. Cable from first floor telecom room 108 runs to hallway 1018. Where cable nears ceiling speaker provide label reading as follows:

"To TR 108" on end towards TR 108

"To hall 1018, speaker 2" on end towards next speaker in line At Head end, cable label to read "to hall 1018, speaker 1" Zone numbering should also be noted if zones are required (zone 1, zone 2, etc.)

#### 3.04 TRAINING

- A. Contractor shall conduct one on-site, hands-on user training sessions, limited to 4 people for one hour. This training will be necessary for all users of the system as determined by the Owner. Contractor shall provide one (1) additional hour of training within sixty days of cutover with no additional charges to the owner. Contractor shall be available by telephone at no additional charge for up to one (1) hour per month for three (3) months following installation to discuss issues with the system.
- B. Training shall include overview of cable routing, terminations, labeling, volume control and toggle switch installation, head-end cable routing and amplifier connection.

#### 3.05 TESTING

- A. Contractor shall be responsible for supplying test equipment and qualified personnel to conduct acceptance tests.
- B. Contractor shall conduct system tests as specified by manufacturer upon completion of installation. Contractor shall test cables and dual input for each floor. Contractor shall provide temporary amplifier and dual input signals in order to test system, or shall return to site once owner has provided amplifier and dual input signal.
- C. Contractor shall conduct tests during course of construction when identifiable portion of installation is complete. Alternatively, testing can be conducted after entire installation is complete if this does not delay the project schedule or affect system functionality.
- D. Contractor shall verify acceptable volumes with owner. Notify owner prior to testing so that owner may accompany contractor to verify appropriate volumes. Make adjustments as required at amplifier or tap settings on speakers.
- E. If tests fail to meet stated specifications, make such adjustments, replacements and changes as are necessary and then repeat tests which disclosed faulty or defective material, equipment or installation method. Provide labor and materials for testing at no additional cost to Owner. The system must complete a successful performance period. The performance period will begin on the day following the completed installation and must continue for 30 consecutive days during which time the system will operate at an average effectiveness level of 99 percent or more. If for any reason this level cannot be maintained, a new 30-day performance period will be initiated. It is not necessary that one 30-day period expire before another performance period begins.

#### F. DOCUMENTATION

1. See section 27 05 10 for requirements.

END OF SECTION

## SECTION 27 5223 – WIRELESS EMERGECY CALL

## PART 1 - GENERAL

- 1.1 SECTION INCLUDES
  - A. Wireless Emergency Call System.

#### 1.2 REFERENCE STANDARDS

- A. Federal Communications Commission (FCC):
  - 1. FCC CFR 47 Part 15 Telecommunications Radio Frequency Devices.
  - 2. FCC CFR 47 Part 68 Telecommunications Connection of Terminal Equipment to the Telephone Network.
- B. Request for Comments (RFC):
  - 1. RFC 1321 MD5 Message-Digest Algorithm.
  - 2. RFC 1757 Remote Network Monitoring Management Information Base.
  - 3. RFC 1918 Address Allocation for Private Internets.
  - 4. RFC 2104 HMAC: Keyed-Hashing for Message Authentication.
- C. UL 2560 Standard for Emergency Call Systems for Assisted Living and Independent Living Facilities.

#### 1.3 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements for submittal procedures.
- B. Product Data: Manufacturer's data, user and installation manuals for all equipment and software programs including computer equipment and other equipment required for complete emergency call system, including:
  - 1. Preparation instructions and recommendations.
  - 2. Storage and handling requirements and recommendations.
  - 3. Installation methods.
- C. Shop Drawings:
  - 1. Detailed wiring diagrams and system description.
  - 2. System device locations on architectural floor plans.
  - 3. Full schematic of system, including wiring information for all devices.
- D. Closeout Submittals: See Section 01 78 00 Closeout Submittals for addition requirements.
  - 1. User manual.
  - 2. Parts list.
  - 3. System device locations on architectural floor plans.
  - 4. Wiring and connection diagram.
  - 5. Maintenance required and maintenance schedule.

#### 1.4 QUALITY ASSURANCE

- A. Manufacturer Qualification:
  - 1. Provide availability of equipment for expansions, replacements, and spare parts available to dealers or end users.
  - 2. Provide factory direct technical support from 8:00 a.m. to 5:00 p.m. via phone, e-mail, or via internet.
- B. Installer Qualification: Manufacture authorized installer and or dealer, or minimum of five years' experience installing emergency call systems, information systems, telephone systems, and devices
- C. After-sales Support: Contractor shall be a factory-authorized and trained dealer of system and shall be factory-trained and certified to maintain system.

#### 1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in manufacturer's original, unopened, undamaged containers; and unharmed original identification labels.
- B. Store products in manufacturer's unopened packaging until ready for installation.
- C. Protect store materials from environmental and temperature conditions following manufacturer's instructions.
- D. Handle and operate products and systems according to manufacturer's instructions.

#### 1.6 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

#### 1.7 WARRANTY

- A. See Section 01 70 00 Execution and Closeout Requirements for additional provisions
- B. Provide manufacturer's standard limited warranty covering products for replacement and repair of defective equipment, equipment included:
  - 1. Server
  - 2. Main receiver
  - 3. Power supply
  - 4. Repeaters
  - 5. Wireless sensors and signal devices.

#### PART 2 - PRODUCTS

- 2.1 MANUFACTURERS
  - E. Acceptable Manufacturer:
    - 1. PalatiumCare, LLC.

#### 2.2 WIRELESS EMERGENCY CALL SYSTEM

- A. Product: PalatiumCare Wireless Emergency Call System as manufactured by PalatiumCare, LLC.
- B. System Overview:

- 1. Emergency call system shall be suitable for informing facility care givers of a request for help by residents or facility occupant.
- 2. System functions include:
  - a) Managed call system to ensure response by care-giver.
  - b) Form C relay connection for third-party sensors or equipment.
  - c) Resident call management data to supplement basic care-giver call for assistance.
  - d) Call history reporting.
  - e) Non-emergency notification transmission to care-givers.
  - f) Self-monitoring capabilities of working status and location of system components including batteries, sensors and wireless devices.
  - g) Resident emergency call from anywhere on facilities property
  - h) Connection into fire panel via RS 232 Serial output connection.
  - i) Connection to Advanced Wireless Communication system.
  - j) Wireless doorbell integrated with staff radio devices.
- 1. Operate 24 hours a day while only being able to turn system off by physically disconnecting power cable or power loss caused by a power outage.
- 2. Notifying care-givers about resident's request for help and or status.
- 3. Customized notification messages presented to care-givers for devices assigned to residents and/or locations through decentralize user-interface by an authorized operator.
- 4. Manage (add, update, delete) livable and non-livable locations through decentralize userinterface by an authorized operator.
- 5. Move residents to livable location listed in system through decentralize user-interface by an authorized operator.
- 6. Relocate residents without having to reassign devices to resident through decentralize userinterface by an authorized operator.
- 7. Move residents out of livable location listed in system through decentralize user-interface by an authorized operator.
- 8. Enter resident assistance information through decentralize user-interface by an authorized operator.
- 9. Assign devices to residents listed in system through decentralize user-interface by an authorized operator.
- 10. Assign devices to a location listed in system through a decentralize user-interface by an authorized operator.
- 11. Customize device functionality pertaining to device type assigned to resident or location through decentralize user interface by an authorized operator.
- D. Compliance:
  - 1. Comply with requirements of UL 2560.
  - 2. System to comply with all applicable international, national and local regulations for design, construction and installation of electrical equipment.
- E. System Configuration:
  - 1. Control position: Comprising a Central Control Unit (or devices) accessible through personal computer and network connection provided by third-party.

- 2. Resident position with facilities for request-for-help.
- 3. Pager notification.
- 4. Email notification.
- 5. Advanced Wireless Communication Integration by Palatium Radio Repeater coverage.
- 6. Interface facilities for external door egress sensors.
- 7. Remote site operation through third-party equipment and internet connection.
- F. System Installation and Interconnection:
  - 1. Installation System: Modular type controlled by central control unit.
  - 2. Battery Backup Wiring Termination: NEMA 5-15R or NEMA 5-20R receptacle.
    - a) Connect to emergency generator if available.
  - 3. Wireless devices connected to central control unit via wireless receiver;
    - a) Wireless Communication Operation: 900 MHz band, with spread spectrum technology.
    - b) Provide secure wireless communications between wireless devices and receiver.
  - 4. Wireless Receiver to Central Equipment Wiring: Special 4-pin serial cable with attached F DB9 serial connection and 12 VDC 200 mA power adapter.
  - 5. Paging Transmitter to Central Equipment Wiring: MF DB9.
    - a) Serial cable cannot exceed 40-feet from central equipment.
    - b) Paging Transmitter Power: 12 VDC 4000 mA power adapter connected to battery backup unit.
    - c) Mount paging transmitter on wall, with 3-foot radius away from other radios and metal objects.
  - 6. Network Connectivity Wiring: Capable of managing central control unit.
    - a) Wiring: Cat 5e, or better copper Ethernet cable, dedicated run from central control unit to central network patch panel or network switch.
  - 7. Central Equipment Wiring: Special twin optical fiber plus two copper cores combined in one cable.
    - a) Use series cabling with option for redundancy (loop-through or series-connected branch topology) for interconnection of central equipment.
    - b) Equipment shall be free-standing (table-top device) or built into 19 inches (483 mm) racks provided under other Sections.
- G. System Operation Levels: Available through third-party resources.
  - 1. Anonymous: Provides only viewing capabilities of current incident status and support contact information.
  - 2. Caregiver: Provides limited system access with managing residents and basic historic reporting.
  - 3. Administrator: Provides system access with resident and location management, site customization, and full historic reporting.

- 4. Tech Support: Provides ability to troubleshoot and view system status for support requests.
- H. Wireless Emergency Call System Functional Description and Equipment:
  - 1. System to provide call location, resident, and device management through easy-to-use interface, with care-giver notification via pager.
  - 2. Bed Station Characteristics:
    - a) Wireless device transmits request-for-help.
    - b) Central control unit displays request while making an audible sound.
    - c) Request is routed to designated pager and/ wireless communication device, informing when request-for-help was initiated, type of device used, bed location, and/or extra informative information such as resident's name.
    - d) Repeats request-for-help until bed station is reset.
    - e) Bed station can only be reset at device that originated request-for-help. Resetting the bed station away from physical device shall not be accepted.
    - F) Basis of Design: PalatiumCare Wireless Bed Station
  - 3. Bathroom and General Indoor Station Characteristics:
    - a) Wireless device transmits request-for-help.
    - b) Central control unit displays request while making an audible sound.
    - c) Request is routed to designated pager and/ wireless communication device, informing when request-for-help was initiated, type of device used, bathroom location, and or extra informative information such as resident's name.
    - d) Request-for-help is repeated until bathroom station is reset.
    - e) Bathroom station can only be reset at device that originated request-for-help. Resetting bathroom station away from the physical device shall not be accepted.
  - 4. Mobile Station Characteristics:
    - a) Wireless device transmits request-for-help.
    - b) Central control unit displays request while making an audible sound.
    - c) Request is routed to designated pager and/ wireless communication device, informing when request-for-help was initiated, the type of device used, resident assigned to mobile emergency button, and/or extra informative information.
    - d) Request-for-help is repeatedly notified until mobile emergency button is reset.
    - e) Mobile station can only be reset at device that originated request-for-help. Resetting the mobile station away from physical device shall not be accepted.
  - 5. Doorbell Station Characteristics (indoor or exterior):
    - a) Wireless doorbell transmits request-for-entry.
    - b) Central control unit displays request while making an audible sound.
    - c) Request is routed to designated pager and/ wireless communication device, informing when request-for-request was initiated, type of device used, doorbell location, and/or extra informative information.
    - d) Request-for-entry is not repeatedly notified.

- 6. Personal Pager:
  - a) Care-giver pager to receive notification of wireless sensors and emergency stations.
  - b) UHF frequency, LCD alphanumeric display, 4 lines 20 characters per line; Battery: AA Alkaline; Weight: 3.1 ounces.
- J. Central Control Equipment:
  - 1. Central Control Unit:
    - a) Central control unit together with wireless receiver forms heart of Wireless Emergency Call System.
  - 2. Wireless Receiver:
    - a) Wireless receiver links central control unit with wireless signals from wireless repeaters, wireless sensors, and emergency stations.
    - 4. Paging Transmitter:
      - a) Paging transmitter sends notifications, automated by central control unit or manually initiated by operator, to pagers.
    - 5. Battery Back-up:
      - a) 600VA / 300 W simulated Sinewave uninterrupted power source, USB connectivity, EMI/RFI filters, audible alarms, resettable circuit breakers, multi-function LED display RJ11/RJ14 protection
      - b) 8 outlets (4 battery back-up, 4 surge only), UPS port
- K. Application Software:
  - 1. Application shall be modular and shall run under operating systems and web browsers that supports Microsoft Silverlight 4.
  - 2. Software modules shall be protected for copying by license key.
- L. Technical Data Wireless Emergency Call System:
  - 1. Wireless Repeater:
    - a) Operating Frequency: 902-928 MHz.
    - b) Battery Life: 8 hours.
  - 2. Wireless Devices Operating Frequency: 902-928 MHz
  - 3. Paging Transmitter Operating Frequency: 467.8000 MHz or 469.7000 MHz
  - 4. System Environmental Conditions:
    - a) Operating Temperature Range: 0 degree C to +60 degree C (32 degree F to 140 degree F).

b) Relative Humidity: 90%, non-condensing.

## PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine existing conditions, verifying that conditions are ready for Work of this Section to proceed; notify Architect conditions are not satisfactory.
- B. Ensure power source is protected against accidental shutoff.
- C. Verify that emergency power source available and adequate for wireless emergency call system.

## 3.2 INSTALLATION

- A. Installation shall be accomplished in accordance with manufacturer's instructions and applicable codes by qualified personnel regularly engaged in and experienced in this type of work.
- B. Mount wireless receiver on wall, with 3-foot radius away from other radios and metal objects.
- D. Mount paging transmitter on wall, with 3-foot radius away from other radios and metal objects.
- E. Terminate central equipment wiring with RJ45 Cat 5e jack, or better Ethernet RJ45 jack, on both ends.
- F. Terminate cable with purpose designed connectors; optical part of connectors to be SC compatible
- G. Run wireless repeater wiring to 3-inch deep by 4-11/16-inch metal junction box and connected to a UL 12-VAC 20-A Class 2 transformer.
  - 1. Connect electrical line to emergency power generator if is provided.
  - 2. Mount junction box on a wall at least 80 inches from floor and no more than 12 inches from celling or mounted above false celling that allows running low-voltage 18-2 wire from junction box to middle of wall and finishing outside of wall.

## 3.3 FIELD QUALITY CONTROL

- A. Submit written test report that system has been 100 percent tested and approved.
  - 1. Owner, Architect, Contractor, and performed by installation contractor shall witness final test.
  - 2. Owner shall receive and acknowledge final test report prior to request for final payment.
- B. Provide instruction to Owner's satisfaction with regard to proper use and operation of system.

#### 3.4 DEMONSTRATION

A. Demonstrate at final inspection that devices functions properly.

#### 3.5 MAINTENANCE

- A. Provide system manufacturer's basic maintenance service for a period of 1 year, including:
  - 1. Software Maintenance with phone support, software updates, and monthly system information backup.
  - 2. Technical Support: Free of charge support, 8 am to 5 pm, CST, Monday through Friday.
  - 3. Extended weekend, nights and holiday service at an additional fee to be listed separately.

END OF SECTION

## SECTION 28 1300 – ACCESS CONTROL

#### PART 1 - GENERAL

#### 1.0 SECTION INCLUDES

- A. Administrator
- B. Installation
- C. Software Management
- D. Integrated Access Control and Security System

#### 1.2 RELATED REQUIREMENTS

- A. Section 08 71 00 Door Hardware: Electrically operated door hardware, for interface with access control system.
- B. Section 28 31 06 Fire Detection and Alarm: For interface with access control system.

#### 1.3 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction; National Electrical Contractors Association; 2010.
- B. NFPA 70 National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. UL 294 Access Control System Units; Current Edition, Including All Revisions.

#### 1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the work with other installers to provide suitable door hardware as required for both access control functionality and code compliance.
  - 2. Coordinate the placement of readers with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 3. Coordinate the work with other installers to provide power for equipment at required locations.
  - 4. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
  - 5. Coordinate the installation scope between the Electrical Contractor, General Contractor and Low Voltage Contractor, prior to installation.
  - 6. Coordinate with Electrical Contractor to provide connection from Security System to electrical system and Fire Alarm system. The connection shall be programmed to cause the Security System to drop all electronic locks upon notification of fire alarm system event and/or power outage. All security locks and magnetic locks shall drop off to permit free egress through all doors in case of such an event.

#### 1.5 SUMMARY

A. General description, functionally requirements, characteristics, and criteria present in the Card Access Control, Alarm Monitoring and Surveillance Integration System.

- B. Card Access System shall provide a wide variety of feature rich functions. These functions are categorized into system modules which include:
  - 1. Access Control management
  - 2. Alarm monitoring Management
  - 3. Surveillance Integration
  - 4. Reporting Management
  - 5. Personnel Management Tracking
  - 6. Visitor Management
  - 7. Building Lock Down
  - 8. Graphic Dynamic Mapping a. Mapping Imported, Viewing and Executable
  - Automated Data Import and Data Export
  - 10. Full Time and Attendance

#### 1.6 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include elevations and details of proposed equipment arrangements. Include system interconnection schematic diagrams. Include requirements for interface with other systems.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- E. Maintenance contracts.
- F. Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.
- G. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  - 1. Include contact information for entity that will be providing contract maintenance and trouble callback service.
- H. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

#### 1.7 QUALITY ASSURANCE

- A. Comply with the following:
  - 1. NFPA 70
  - 2. The requirements of the local authorities having jurisdiction.
  - 3. Applicable TIA/EIA standards.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Installer Qualifications: Company specializing in performing the work of this section with minimum three years documented experience with access control systems of similar size, type, and complexity and

providing contract maintenance service as a regular part of their business; authorized manufacturer's representative.

- 1.8 DELIVERY, STORAGE, AND HANDLING
  - A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
  - B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.
- 1.9 FIELD CONDITIONS
  - A. Maintain field conditions within manufacturer's required service conditions during and after installation.

#### 1.10 WARRANTY

- A. See Section 01 78 00 Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

#### PART 2 - PRODUCTS

- 2.1 MANUFACTURERS
  - A. CDVI
  - B. Brivo "on-site"
  - C. OSSI/Accutech
- 2.2 ACCESS CONTROL SYSTEM REQUIREMENTS
  - A. Provide an integrated access control system and Security System consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.

## 2.3 SYSTEM DESCRIPTION

- A. The Ethernet communicating integrated Access Control and Security System's primary function, is to allow businesses to regroup all of their security system installations ito 1 (one) system, no matter what the distance is between each one.
- B. The integrated Access Control and Security System, can be installed in each of the locations necessary which will all be regrouped and related to 1 (one) central secure database. Various workstations can be managed and distributed in different buildings (locations) in order to administer and mage various users as well as other parameters in the access control system.
- C. The integrated Access Control and Security System, comprised of an intelligent architecture having a distributed database, allows for allocation of relevant information through the various modules installed thus, providing increased performance. This information is shared and / or distributed by various communication networks, Ethernet / internet available in the facilities. The Central Server provides security for this information by using advanced protection protocols.
- D. The system also features a power output of 12V allowing for the connection of sirens up to a maximum of 45 watts.
- E. Integrations and locking Configurations shall comply with all Local and State Code Requirements.

- 1. Locking in the path of egress shall unlock upon activation of the fire sprinkler system
- 2. Locking in the path of egress shall unlock upon activation of any heat detector or any one or two smoke detectors.
- 3. Locking in the path of egress shall unlock upon the loss of power that controls the lock.
- 4. Locking in the path of egress shall unlock within 15 seconds, or 30 seconds when approved by the AHJ, when the release device is held for more that 3 seconds.
- 5. The force required to activate the release device must be less than 15 lbf.
- 6. The release process for the lock shall activate an audible signal in the vicinity of the door.
- 7. The door lock must be manually reset after being released.
- 8. A sign must be provided on the door next to the release device indicating "Push Until Alarm Sounds" & "Door Can Be Opened In 15 Seconds"

## 2.4 SYSTEM ARCHITECTURE

- A. The integrated Access Control and Security System and its various peripherals and features and functionalities.
  - 1. Database Server
    - a. Installed on a centralized computer server within a single facility or remote location.
    - b. Hardware server hosts the access control software server in a secure location.
    - c. Secured location is always accessible locally or remotes, 24 hours a day, 7 days a week, 365 days a year by all authorized personnel.
    - d. Recommended to prover server hardware with emergency power source in the event of power failure of primary power source.
    - e. Recommended regular maintenance of server hardware and software set to ensure optimal operation.
    - f. Provide an interval archiving procedure.
    - g. Automatic updating and / or reminder for software updates, for the control station and for device software, must be implemented. Software upgrades are effective immediately.
    - h. Control / management software must contain contact information in order to obtain adequate assistance when necessary.
  - 2. Web Server
    - a. Provides an embedded web server included directly to access control controller.
    - b. Embedded Web Server allows access by various Web Browsers.
    - c. The access control solution shall support connectivity through both web browser and client / server architecture.
    - d. Basic configurations and consulting functions are offered by using a standard Web browser.
    - e. The access control system shall provide an integrated system allowing usage without Client / Server software.
  - 3. Authentication and Encryptions
    - a. All commands between the web browser and the system are protected, encrypted by various protocols including RC4 and MD5.
    - b. All communications between the Server Software and the system are protected, encrypted by AES protocol with a 256-bit key.
- c. All network communications between the system and all its peripherals are protected by a proprietary protocol.
- d. All network communications between the system and all peripherals will be protected by a proprietary protocol for rapid high performance.
- e. All communications between the system and the web browser must first be authenticated and authorized.
- f. All communications between the system and server software must first be authenticated and authorized.
- g. All communication between the system and its peripherals must first be authenticated and authorized.
- 4. Network Access via Broadband
  - a. The system should communicate with the central data server via Internet, a corporate Ethernet network of a cellular network.
  - b. The system must be connected directly to the main control panel via Ethernet connection.
  - c. The main control panel needs to be equipped with an RJ45 connector to allow connection to a corporate Ethernet network or an internet network via a Category 5e/6 network cable.
- 5. Central Data Storage Units
  - a. All Client data and all configuration settings of control panels and peripherals will be centralized in a central database and will be distributed to each of the controls pnaels and peripheral storage units.
  - b. Access Control Management Software will provide a mechanism for scheduled local or remote automated backup to preserve all information in the system.

# 2.5 SOFTWARE AND SERVER

- A. Access Control system configuration settings by means of connectivity via local software, connection to a central server or web browser.
  - 1. Features and key functions of the system.
    - a. Provides central backup of the system information managed web access and or the workstation Client software.
    - b. Allows for database backup and restore as well as data archiving capabilities.
    - c. History of time stamped events.
    - d. Allows for multiple managers to simultaneously personalize their client accounts.
    - e. Allows the user to perform system configurations to ensure the security of its installations and its information.
    - f. Allows the user to customize schedules in order to maintain the installation and the testing of certain devices.
    - g. Provides a robust communication for the exchange between all system components are effective, reliable and secure.
    - h. Allows administrators to define and manage their installations and their various access points.
    - i. Define different levels of users by providing different level of access and authorization within the software and the system.
    - j. Supervision of actions taken by the various users across the whole system.

- k. Active management of all pieces of ID associated with an account, a user or a Community.
- I. Detailed history of all system activities including attempts to access without proper credentials.
- m. Provisions of a protection system that allows administrators to deny rights or access to certain users or groups of users.
- n. Configuration of email transmission initiated by the occurrence of certain events or situations.
- o. Ability to create detailed reports of certain activities such as requests for denied access.
- 2. Custom Schedules
  - a. The system will offer a multitude of schedules with programmable time periods, modifiable and usable for both user rights and for the automatic locking of the doors.
  - b. Assignments of these schedules for user groups, schedules for unlocking doors and the activation of certain units.
  - c. The addition or withdrawal of schedules to and from a user group.
  - d. The addition or removal of periods for unlocking of doors.
  - e. Adding or removing schedules for a group of control devices.
  - f. The addition, deletion and modification of one or more periods of time in a schedule.
  - g. The combination of days or holiday periods to one or more schedules.
  - h. The combination of days or holiday periods to one or more doors.
  - i. The ability to configure the time and date of commencement and the duration of one day or a holiday period.
  - j. The addition, deletion and modification of one or more holiday periods.
- 3. Site Management
  - a. The integrated system will allow account administration the creation and management of accounts including all their associated equipment, such as control panels, doors, areas and peripherals.
    - 1. Definition and management of control panel accounts.
    - 2. Creation and management of sites.
    - 3. Addition of doors to a site and their associations to control panels.
    - 4. Activation and deactivation of the supervision of doors left open and the definition of the acceptable length of opening.
    - 5. Threshold definition for the invalidation of code users and the blocking period attached.
    - 6. Defining and editing of the access schedules
    - 7. Management of request to exit detection.
    - 8. Activation and deactivation of I/O of individuals by some or all of the access points.
    - 9. Addition of creating email notification.
    - 10. Addition of an IP camera (1 per door)
    - 11. Configuration of the intrusion integration
    - 12. Definition and monitoring of indications of alarm conditions and the definition of possible alarm conditions.
    - 13. Adding and removing doors to a site.
    - 14. Adding peripherals to a site and the association of these devices to control panels.
    - 15. Configuration of the behavior of a device.
    - 16. Configuration of the tracking events in history.
    - 17. Removal of devices on a site.

- 18. Definition and the modification of unlocking and / or schedules for a door.
- 19. Addition of a partition
- 20. Withdrawal of a partition
- 21. Definition of a partition of an area or an area delimited by doors.
- 22. Specifying the crossing points (doors) and their adjacent partitions (areas).
- 4. Administration of Rights by Level
  - a. The integrated system will provide administration of users by floor to allow the administrator to create user subordinates. Each of these users will have a unique ID and password indicating within the system, everyone's individual rights for consultation, editing and management of information.
    - 1. Each account should only have one single chief administrator. The administrator can configure and manage all data for the accounts and perform the addition or removal of a user. The Administrator has full rights.
    - 2. System shall maintain and provide all actions taken by administrators. The software shall obtain a permanent trace of records.
- 5. ID Management
  - a. The software will support the management of documents such as identity cards, PINS, user codes associated with a user account and their owner. Custom Schedules.
  - b. Addition of different card formats (Wiegand 26-bit, 30-bit and 44-bit formats, as well as magnetic stripe cards TRACK2.
  - c. Association and the removal of card assignments.
  - d. Removal of cards from the card database.
- 6. Event History Management
  - a. The software will record all attempts to access various sites associated with an account and maintain this information in a history log accessible by administrators of the account.
    - 1. Display all events stored in history
    - 2. Display all event stored in history sorted by User.
    - 3. Displaying all events stored in history sorted by door.
    - 4. Displaying all events stored in history sorted by peripheral.
    - 5. Displaying all events stored in history limiting the number of results.
    - 6. Possibility to search results based on User, Peripherals, Doors, Sites, time period or specific date.

## 2.6 PRODUCTS

- A. Access Control System Control Panel
  - 1. Control panel supports various card reader technologies including wiegand standard and the standard track2.
    - a. Proximity card reader

- b. Wiegand effect reader
- c. Wiegand keypad
- d. Track2 magnetic card reader
- 2. Power Requirements
  - a. Control panel must be powered by a standard AC outlet, 120VAC or 240VAC, 50 or 60Hz.
  - b. Control panel shall be equipped with a backup battery 12VDC and provide the following features:
    - 1. Indication of source of its power, primary or backup.
    - 2. Transmit a signal to the software indicating the transfer of power from the primary source to the backup battery and vice versa.
    - 3. Indication within the software the system is powering up, starting and / or restarting.
    - 4. Control Circuits
  - a. The access control system, powerful web-based IP module. The flexibility of the A22 module allows it to be set either as a 2-door controller or a 2-door expander. When set, a controller (IP connectivity) each A2 supports up to 100 expansion modules on their RS485 network. These modules include the following with their maximum capacity:
    - 1. Up to ten A22, set as a controller (IP connectivity).
    - 2. Up to forty A22, set as an expander (RS485 connectivity), four per A22 set as a controller.
  - b. A22 Web-Based IP module provides the following input and outputs:
    - 1. RS485 (1) Communication port
    - 2. Ethernet 10/100 (1) Communication port
    - 3. Module jumper setting (1) to set as a controller or expander
    - 4. Reader interfaces (2)
    - 5. Assignable zone input, home automation and access (6)
      - i. Door contact (2)
      - ii. Exit request (2)
      - iii. Entry request (2)
    - 6. Relay door bypass activation (2)
    - 7. Entry tamper detection (1)
    - 8. Intelligent power output (3)
    - 9. Door lock output (2)
    - 10. Auxiliary relay (2)
    - 11. Low power output (2)
    - 12. Battery backup output (1)
- 4. Readers
  - a. Mullion Proxmimity Reader
    - 1. Mulitcolour LED
    - 2. -30 to 60 Degree C
    - 3. Power 12VDC
    - 4. Color: White or Black

- b. Standard Proximity Reader
  - 1. Multicolour LED
    - 2. Audible Feedback
    - 3. -30 to 60 Degree C
    - 4. Power 12VDC
  - 5. Color: White or Black
- c. Software
  - 1. Advanced and power access control management tool. Allows the operator to monitor and manage the system by accessing system by accessing the controller using a network connection.
  - 2. Fully featured and comprehensive monitoring and management capabilities.
  - 3. Provides integrated surveillance monitoring and alarm management.
  - 4. Full building control and monitoring of building access and system diagnostics.

## 5. Wireless Lock

- a. Wireless Lock, or approved equal.
  - 1. Wireless locks configures to fit into a standard cylindrical door prep.
  - 2. Wireless lock features a built in door position sensor on the lock and strike plate.
  - 3. Lock can be configured for a right or left handed door.
  - 4. Powered by (4) AA batteries with up to two years life under normal usage.
  - 5. Compatibility with most leading key systems.
  - 6. Standard finish shall match the Community standard, approved by Owner prior to purchase.
  - 7. Stand along applications used to manage locks, add and delete credentials and view lock history.
  - 8. Locks are wifi enabled and shall connect to the IT network for daily updates. Updates are scheduled for automatic updates within a 24 hour period of the requested change. Immediate push of changes to lock can be done by immediate push of content via the cloud based software.
  - 9. Locks provide details auditing and real time monitoring.
  - 10. Locks shall be defined by access privileges and manage schedules.

# 2.7 ACCESS CONTROL POINT PERIPHERALS

- A. Provide devices compatible with control units.
- B. Provide devices suitable for operation under the service conditions at the installed location.
- C. Door Position Switches
  - 1. Magnetic Contacts: Encapsulated reed switch(es) and separate magnet; designed to monitor opened/closed position of doors.
  - 2. Contact Color: Brown.
  - 3. Product(s):
    - a. Securitron DPS-M (Metal Doors)
    - b. Securitron DPS-W (Wood Doors)
    - c. Approved equal.

PART 3 - EXECUTION

- 3.1 EXAMINATION
  - A. Verify that field measurements are as shown on the drawings.
  - B. Verify that ratings and configurations of system components are consistent with the indicated requirements.
  - C. Verify that mounting surfaces are ready to receive system components.
  - D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to system.
  - E. Verify that conditions are satisfactory for installation prior to starting work.

### 3.2 INSTALLATION

- A. Install access control system in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Provide grounding and bonding in accordance with Section 26 05 26.
- D. Identify system wiring and components in accordance with Section 26 05 53.

### 3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 Quality Requirements, for additional requirements.
- B. Prepare and start system in accordance with manufacturer's instructions.
- C. Program system parameters according to requirements of Owner.
- D. Test for proper interface with other systems.
- E. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.

## 3.4 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

#### 3.5 CLOSEOUT ACTIVITIES

- A. See Section 01 79 00 Demonstration and Training, for additional requirements.
- B. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- C. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of four hours of training.
  - 3. Instructor: Manufacturer's authorized representative.
  - 4. Location: At project site.

## 3.6 MAINTENANCE

- A. Provide to Owner, a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of access control system for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.
- B. Conduct site visit at least once every three months to perform inspection, testing, and preventive maintenance. Submit report to Owner indicating maintenance performed along with evaluations and recommendations.

## **END OF SECTION**

# SECTION 28 2300 – VIDEO SURVEILLANCE

# PART 1 - GENERAL

## 1.1 SECTION INCLUDES

- A. Video surveillance system requirements.
- B. Video recording and viewing equipment.
- C. Cameras.
- D. Accessories.

## 1.2 RELATED REQUIREMENTS

- A. Section 07 84 00 Firestopping.
- B. Section 28 13 00 Access Control: For interface with video surveillance system.

# 1.3 REFERENCE STANDARDS

- A. NECA 1 Standard for Good Workmanship in Electrical Construction; National Electrical Contractors Association; 2010.
- B. NECA 303 Standard for Installing Closed-Circuit Television (CCTV) Systems; National Electrical Contractors Association; 2005.
- C. NFPA 70 National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

## 1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the placement of cameras with structural members, ductwork, piping, equipment, luminaires, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
  - 2. Coordinate the work with other installers to provide power for cameras and equipment at required locations.
  - 3. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Preinstallation Meetings:
  - 1. Conduct meeting with facility representative to review camera and equipment locations and camera field of view objectives.
  - 2. Conduct meeting with facility representative and other related equipment manufacturers to discuss video surveillance system interface requirements.

## 1.5 SUBMITTAL

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

- B. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include elevations and details of proposed equipment arrangements. Include system interconnection schematic diagrams. Include requirements for interface with other systems.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- E. Manufacturer's detailed field testing procedures.
- F. Field quality control test reports.
- G. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  - 1. Include contact information for entity that will be providing contract maintenance and trouble callback service.
- H. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- I. Maintenance contracts.

# 1.6 QUALITY ASSURANCE

- A. Comply with the following:
  - 1. NFPA 70
  - 2. Applicable TIA/EIA standards.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Installer Qualifications: Company specializing in performing the work of this section with minimum three years documented experience with video surveillance systems of similar size, type, and complexity and providing contract maintenance service as a regular part of their business; authorized manufacturer's representative.
- 1.7 DELIVERY, STORAGE, AND HANDLING
  - A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions and NECA 303.
  - B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

# 1.8 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

## 1.9 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

# PART 2 - PRODUCTS

- 2.1 MANUFACTURERS
  - A. Manufacturers:
    - 1. Cameras: AXIS
    - 2. Video management system and storage: AXIS compatible
- 2.2 VIDEO SURVEILLANCE SYSTEM
  - A. Provide new video surveillance system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
  - B. System Description: IP system with connection to network (IP) cameras.
    - 1. Video Storage Capacity: Suitable for storing video from all cameras for 30 days.
    - 2. System Battery Backup: Provide batteries/uninterruptible power supplies (UPS) as required for 60 minutes full operation.
    - 3. Surge Protection:
      - a. Provide surge protection for exterior cameras.
      - b. Provide equipment power surge protection where electrical distribution system surge protection is not provided.
      - c. Manufacturer: DITEK
  - B. Cameras Required:
    - 1. See article "CAMERAS" below for product descriptions.
  - C. Video Recording and Viewing Equipment Required:
    - 1. See article "VIDEO RECORDING AND VIEWING EQUIPMENT" below for product descriptions.
  - E. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
  - F. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 15, for Class B, consumer application.
- 2.3 VIDEO RECORDING AND VIEWING EQUIPMENT
  - A. Provide video recording and viewing equipment compatible with cameras to be connected.
  - B. Network Video Recorders (NVRs):
    - 1. Supports connection of network (IP) cameras.

- 2. Supports continuous and event-based recording.
- 3. Network Video Recorder:
  - a. Basis of Design:
  - b. Capacity: 32 channels.
  - c. Recording and Viewing Performance: 180 fps at 1.3M resolution.
  - d. Storage Capacity: 20 TB.
  - e. Removable Media: DVD-RW, USB.
  - f. Network: Single 1 Gigabit Ethernet.
- D. Computers:
  - 1. Workstation Computers: Unless otherwise indicated, workstation computer hardware not furnished by video surveillance system manufacturer to be provided by others, meeting video surveillance system equipment manufacturer's minimum requirements.
  - Servers: Unless otherwise indicated, server hardware not furnished by video surveillance system manufacturer to be provided by others, meeting video surveillance system equipment manufacturer's minimum requirements.
- E. Software:
  - 1. Unless otherwise indicated, provide all software and licenses required for fully operational system.

### 2.4 CAMERAS

- A. Provide cameras and associated accessories suitable for operation under the service conditions at the installed location. Provide additional components (e.g. enclosures, heaters, blowers, etc.) as required.
- B. Where not factory-installed, provide additional components (e.g. lenses, mounting accessories, etc.) as necessary for complete installation.
- C. Network (IP) Cameras:
  - 1. Signal-to-Noise Ratio: Not less than 50 dB.
  - 2. Provide the following standard features:
    - a. Automatic electronic shutter.
    - b. Automatic gain control.
    - c. Automatic white balance.
    - d. Web-based interface for remote viewing and setup.
    - e. Password protected security access.
  - 2. Network (IP) Indoor Dome Hallway Linear View
    - a. Image Sensor: 1/2.9" 2.19M CMOS
    - b. Resolution: Up to 1080p (1920x1080).
    - c. Frame Rate: 30 fps with power line frequency 50/60Hz
    - d. Lens: Fixed Auto Iris
    - e. Video Streaming: Multiple, individually configurable streams in H.264 and Motion JPEDControllable frame rate and bandwidth VBR/CBR H.264.
    - f. Power: Ethernet supply IEEE 802.3af/802.at at Type 1, Class 1, Max 3.2 W.
    - g. Features:
      - 1) Video motion detection capability.

## 2) Tamper proof

- 4. Network (IP) Indoor Dome Wide Distribution
  - a. Sensor: 1/2.8" 2.38M CMOS
  - b. Resolution: Up to 1080p (1920x1080).
  - c. Frame Rate: 60 fps with power line frequency 50/60Hz
  - d. Lens: Fixed, 2.8mm
  - e. Video Streaming: Multiple, individually configurable streams in H.264 and Motion JPED Controllable frame rate and bandwidth VBR/CBR H.264.
  - f. Power: Ethernet supply IEEE 802.3af/802.at at Type 1, Class 1, Max 3.2 W.
  - g. Features:
    - 1) Video motion detection capability.
    - 2) Face detection
    - 3) Tamper proof
- 5. Network (IP) Exterior Dome Camera Heater by POE
  - a. Image Sensor: 1/1.8: 6M CMOS
  - b. Resolution: Up to 5M Mode: 25992 x 1944
    - 1. Up to 2M Mode: 1280 x 720
  - c. Frame Rate: 20fps for all resolutions
  - d. Lens: DC Auto Iris
  - e. Video Compression Format: H.264 MJPEG
  - f. Power: Ethernet supply IEEE 802.3af/802.at at Type 1, Class 1, Max 14.2 W.
- C. Camera Enclosures and Mounting Brackets:
  - 1. Where not factory-installed, provide accessory camera enclosures suitable for operation under the service conditions at the installed location.
  - 2. Where not factory-installed, provide accessory camera mounting brackets necessary for installation.
  - 3. Reference mounting requirements on drawings.

## 2.5 ACCESSORIES

- A. Provide components as indicated or as required for connection of video surveillance system to devices and other systems indicated.
- B. Provide network switches as required for network connections to system components.
- C. Provide cables as indicated or as required for connections between system components.
  - 1. Data Cables for IP Network Connections: Unshielded twisted pair (UTP), Category 6, for video transmission.
- D. Provide accessory racks/cabinets as indicated or as required for equipment mounting.

## PART 3 - EXECUTION

- 3.1 EXAMINATION
  - A. Verify that field measurements are as shown on the drawings.
  - B. Verify that ratings and configurations of system components are consistent with the indicated requirements.

- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to system.
- E. Verify that conditions are satisfactory for installation prior to starting work.

# 3.2 INSTALLATION

- A. Install video surveillance system in accordance with NECA 1 (general workmanship) and NECA 303.
- B. Install products in accordance with manufacturer's instructions.
- C. Provide required support and attachment to related components and systems.
- D. Wiring Method: Unless otherwise indicated, use cables (not in conduit).
  - 1. Use suitable listed cables in wet locations, including underground raceways.
  - 2. Use suitable listed cables for vertical riser applications.
  - 3. Use listed plenum rated cables in spaces used for environmental air.
  - 4. Conceal all cables unless specifically indicated to be exposed.
  - 5. Route exposed cables parallel or perpendicular to building structural members and surfaces.
- E. Provide grounding and bonding.
- F. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- G. Identify system wiring and components.
- H. Install and configure video management system and recording hardware and software in accordance with manufacturer's recommendations.
- 3.3 FIELD QUALITY CONTROL
  - A. See Section 01 40 00 Quality Requirements, for additional requirements.
  - B. Provide services of a manufacturer's authorized representative to perform inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
  - C. Prepare and start system in accordance with manufacturer's instructions.
  - D. Adjust cameras to provide desired field of view and produce suitable images under all service lighting conditions.
  - E. Program system parameters according to requirements of Owner.
  - F. Test for proper interface with other systems.
  - G. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.
  - H. Submit detailed reports indicating inspection and testing results and corrective actions taken.

# 3.4 CLEANING

Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

## 3.5 CLOSEOUT ACTIVITIES

A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.

- B. See Section 01 79 00 Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- D. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of four hours of training.
  - 3. Instructor: Manufacturer's authorized representative.
  - 4. Location: At project site.

# 3.6 MAINTENANCE

- A. See Section 01 70 00 Execution Requirements, for additional requirements relating to maintenance service.
- B. Provide to Owner, at no extra cost, a separate maintenance contract for the service and maintenance of video surveillance system for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.
- C. Conduct site visit at least once every year to perform inspection, testing, and preventive maintenance. Submit report to Owner indicating maintenance performed along with evaluations and recommendations.

# END OF SECTION

## SECTION 28 3100 - FIRE DETECTION AND ALARM

PART 1 - GENERAL

### 1.1 SUMMARY

- A. This Section includes fire alarm systems with manual stations, detectors, signal equipment, controls, and devices.
- B. Related Sections include the following:
  - 1. Division 08 Section "Door Hardware".

## 1.2 DEFINITIONS

- A. FACP: Fire alarm control panel.
- B. LED: Light-emitting diode.
- C. Definitions in NFPA 72 apply to fire alarm terms used in this Section.
- D. NICET: National Institute for Certification in Engineering Technologies.

## 1.3 SYSTEM DESCRIPTION

A. General: Digital-addressable system with manual and automatic alarm initiation; automatic sensitivity control of certain smoke detectors; and multiplexed signal transmission dedicated to fire alarm service only.

## 1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
  - 1. Shop Drawings shall be prepared by persons with the following qualifications:
    - a. Trained and certified by manufacturer in fire alarm system design.
    - b. Fire alarm certified by NICET, minimum Level III.
  - 2. Wiring Diagrams: Detail wiring and differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.
  - 3. Battery: Sizing calculations.
  - 4. Floor Plans: Indicate final outlet locations and routings of raceway connections.

- 5. Alarm Characteristics: Indicate the visual strobe candela and audible sound level requirements to satisfy NFPA 72 and the Authority having jurisdiction.
- 6. Device Address List: Coordinate with final system programming.
- 7. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
- 8. Ductwork Coordination Drawings: Plans, sections, and elevations of ducts, drawn to scale and coordinating the installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, the detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
- 9. Voice/Alarm Signaling Service: Equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
- C. Operating Instructions: For mounting at the FACP.
- D. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.
- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Comply with NFPA 72.
- F. Maintenance Data: For fire alarm systems to include in maintenance manuals specified in Division 01. Comply with NFPA 72.
- G. Submissions to Authorities Having Jurisdiction: In addition to distribution requirements for Submittals specified in Division 01 Section "Submittal Procedures," make an identical submission to authorities having jurisdiction, (Department of Labor & Economic Growth, Office of Fire Safety, P.O. Box 30254, Lansing, Michigan, 48909). Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.
- H. Certificate of Completion: Comply with NFPA 72.
- I. Comply with NFPA 20 for fire pump installations.
- J. Inspector's qualifications for the smoke control system.
- K. Smoke control system's test results.

## 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is a trained and certified representative of the FACP manufacturer for both installation and maintenance of units required for this Project.
- B. Manufacturer Qualifications: A firm experienced in manufacturing systems similar to those indicated for this Project and with a record of successful in-service performance.
- C. Source Limitations: Obtain fire alarm system components through one source from a single manufacturer.

- D. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.
- E. Comply with NFPA 72.

### 1.6 SEQUENCING AND SCHEDULING

- A. Existing Fire Alarm Equipment: Maintain fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire alarm equipment "NOT IN SERVICE" until removed from the building.
- B. Equipment Removal: After acceptance of the new fire alarm system, remove existing disconnected fire alarm equipment and restore damaged surfaces.

## PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Edwards Systems Technology; Unit of General Signal.
  - 2. Faraday, Inc.
  - 3. National Time and Signal Corporation.
  - 4. Notifier; a GE-Honeywell Company
  - 5. Siemens Building Technologies, Inc.; a Cerberus Division.

#### 2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. Control of System: By the FACP.
- B. System Supervision: Automatically detect and report open circuits, shorts, and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
- C. Priority of Signals: Automatic alarm response functions resulting from an alarm signal from one device are not altered by subsequent alarm, supervisory, or trouble signals. An alarm signal is the highest priority. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even when the lower-priority condition occurs first. Annunciate and display all alarm, supervisory, and trouble signals regardless of priority or order received.
- D. Noninterference: A signal from one device shall not prevent the receipt of signals from other devices.
- E. System Reset: All devices are manually resettable from the FACP after initiating devices are restored to normal.

- F. Transmission to Remote Alarm Receiving Station: Automatically route alarm, supervisory, and trouble signals to a remote alarm station by means of a digital alarm communicator transmitter and telephone lines.
- G. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground or open circuit occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.
- H. Loss of primary power at the FACP initiates a trouble signal at the FACP. The FACP indicates when the fire alarm system is operating on the secondary power supply.
- I. Basic Alarm Performance Requirements: Unless otherwise indicated, operation of a manual station, automatic alarm operation of a smoke or flame or heat detector, or operation of a sprinkler flow device initiates the following:
  - 1. Notification-appliance operation.
  - 2. Identification at the FACP and the remote annunciator of the device originating the alarm.
  - 3. Transmission of an alarm signal to the remote alarm receiving station.
  - 4. Unlocking of electric door locks in designated egress paths.
  - 5. Release of fire and smoke doors held open by magnetic door holders.
  - 6. Shutdown of fans and other air-handling equipment serving area when alarm was initiated.
  - 7. Closing of smoke dampers in air ducts of system serving area where alarm was initiated.
  - 8. Recording of the event in the system memory.
- J. Alarm Silencing, System Reset and Indication: Controlled by switches in the FACP.
  - 1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
  - 2. Subsequent alarm signals from other devices reactivate notification appliances until silencing switch is operated again.
- K. Water-flow alarm switch operation initiates the following:
  - 1. Notification-appliance operation.
  - 2. Flashing of the device location-indicating light for the device that has operated.
- L. Smoke detection for detectors with alarm verification initiates the following:
  - 1. Audible and visible indication of an "alarm verification" signal at the FACP.
  - 2. Activation of a listed and approved "alarm verification" sequence at the FACP and the detector.
  - 3. Recording of the event in the system memory.
  - 4. General alarm if the alarm is verified.
  - 5. Cancellation of the FACP indication and system reset if the alarm is not verified.
- M. Sprinkler valve-tamper switch operation initiates the following:
  - 1. A supervisory, audible, and visible "valve-tamper" signal indication at the FACP and the annunciator.
  - 2. Flashing of the device location-indicating light for the device that has operated.
  - 3. Recording of the event in the system memory.

- 4. Transmission of supervisory signal to remote alarm receiving station.
- N. Fire-pump power failure, including a dead-phase or phase-reversal condition, initiates the following:
  - 1. A supervisory, audible, and visible "fire-pump power failure" signal indication at the FACP and the annunciator.
  - 2. Recording of the event in the system memory.
  - 3. Transmission of trouble signal to remote alarm receiving station.
- O. Fire-pump running condition, initiates the following:
  - 1. A supervisory, audible, and visible "fire-pump running" signal indication at the FACP and the annunciator.
  - 2. Recording of the event in the system memory.
  - 3. Transmission of trouble signal to remote alarm receiving station.
- P. Fire-pump alternate power supply condition, initiates the following:
  - 1. A supervisory, audible, and visible "alternate power source supplying fire-pump" signal indication at the FACP and the annunciator.
  - 2. Recording of the event in the system memory.
  - 3. Transmission of trouble signal to remote alarm receiving station.
- Q. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system initiates the following:
  - 1. A supervisory, audible, and visible "sprinkler trouble" signal indication at the FACP and the annunciator.
  - 2. Flashing of the device location-indicating light for the device that has operated.
  - 3. Recording of the event in the system memory.
  - 4. Transmission of trouble signal to remote central station.
- R. Remote Detector Sensitivity Adjustment: Manipulation of controls at the FACP causes the selection of specific addressable smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity-adjustment schedule changes are recorded in system memory.
- S. Removal of an alarm-initiating device or a notification appliance initiates the following:
  - 1. A "trouble" signal indication at the FACP and the annunciator for the device or zone involved.
  - 2. Recording of the event in the system memory.
  - 3. Transmission of trouble signal to remote alarm receiving station.
- T. Printout of Events: On receipt of the signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble), and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including the same information for device, location, date, and time. Commands initiate the printout of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

U. FACP Alphanumeric Display: Plain-English-language descriptions of alarm, supervisory, and trouble events; and addresses and locations of alarm-initiating or supervisory devices originating the report. Display monitoring actions, system and component status, system commands, programming information, and data from the system's historical memory.

## 2.3 MANUAL PULL STATIONS

- A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.
  - 1. Double-action mechanism requires two actions, such as a push and a pull, to initiate an alarm. Break glass/plastic stations are not acceptable.
  - 2. Station Reset: Key or wrench operated; double pole, double throw; switch rated for the voltage and current at which it operates.
  - 3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false alarm operation.
  - 4. Integral Addressable Module: Arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.

# 2.4 SMOKE DETECTORS

- A. General: Include the following features:
  - 1. Operating Voltage: 24-V dc, nominal.
  - 2. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
  - 3. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
  - 4. Integral Visual-Indicating Light: LED type. Indicates detector has operated.
  - 5. Sensitivity: Can be tested and adjusted in-place after installation.
  - 6. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
  - 7. Remote Controllability: Unless otherwise indicated, detectors are analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
- B. Photoelectric Smoke Detectors: Include the following features:
  - 1. Sensor: LED or infrared light source with matching silicon-cell receiver.
  - 2. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
  - 3. Integral Thermal Detector: Fixed-temperature type with 135 deg F (57 deg C) setting.
- C. Beam-Type Smoke Detector: Each detector consists of a separate transmitter and receiver with the following features:

- 1. Adjustable Sensitivity: More than a six-level range, minimum.
- 2. Linear Range of Coverage: 330 feet (100 m), minimum.
- 3. Tamper Switch: Initiates trouble signal at the central FACP when either transmitter or receiver is disturbed.
- 4. Separate Color-Coded LEDs: Indicate normal, alarm, and trouble status. Any detector trouble, including power loss, is reported to the central FACP as a composite "trouble" signal.
- 5. Detectors with prism reflectors are not acceptable.
- D. Duct Smoke Detector: Photoelectric type.
  - 1. Photoelectric Smoke Detectors:
    - a. Sensor: LED or infrared light source with matching silicon-cell receiver.
    - b. Detector Sensitivity: Between 2.5 and 3.5 percent/foot(0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
  - 2. UL 268A listed, operating at 24-V dc, nominal.
  - 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
  - 4. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plugin module that connects to a fixed base. The fixed base shall be designed for mounting directly to the air duct. Provide terminals in the fixed base for connection to building wiring.
  - 5. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
  - 6. Integral Visual-Indicating Light: LED type. Indicating detector has operated and power-on status. Provide remote status and alarm indicator and test station where indicated.
  - 7. Sampling Tubes: Design and dimensions as recommended by manufacturer for the specific duct size, air velocity, and installation conditions where applied.
  - 8. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit. Motor shutdown wiring by Temperature Control Supplier.

# 2.5 OTHER DETECTOR

- A. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or rate of rise of temperature that exceeds 15 deg F (8.3 deg C) per minute, unless otherwise indicated.
  - 1. Mounting: Plug-in base, interchangeable with smoke detector bases.
  - 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

# 2.6 NOTIFICATION APPLIANCES

- A. Description: Equip for mounting as indicated and have screw terminals for system connections.
  - 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.
- B. Chimes, High-Level Output: Vibrating type, 81 dB minimum rated output.

- C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Horns produce a sound-pressure level of 90 dB, measured 10 feet (3 m) from the horn. Beige or lvory color.
  - 1. Where installed in sleeping areas, provide square wave signal with fundamental frequency of 520 Hz +- 10% per NFPA-72
- D. Visible Alarm Devices: Xenon strobe lights listed under UL 1971 with clear or nominal white polycarbonate lens. Mount lens on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch (25-mm-) high letters on the lens. Beige or lvory color.
  - 1. Rated Light Output: 15, 30, 75, or 110 candela, as required to satisfy NFPA 72 requirements.
  - 2. Strobe Leads: Factory connected to screw terminals.
  - 3. Strobes shall be sychronized.
- E. Voice/Tone Speakers:
  - 1. High-Range Units: Rated 2 to 15 W.
  - 2. Low-Range Units: Rated 1 to 2 W.
  - 3. Mounting: Flush, semirecessed, surface, or surface-mounted; bi-directional as indicated.
  - 4. Matching Transformers: Tap range matched to the acoustical environment of the speaker location.
- F. Fire Connection Strobe: Provide all required connections to the strobe/horn associated with the fire fighters hose connection on the exterior of the building. Provide 120V power from nearest panel for devices provided by sprinkler system supplier. Connect to emergency power when available.

# 2.7 REMOTE DEVICE LOCATION-INDICATING LIGHTS AND IDENTIFICATION PLATES

A. Description: LED indicating light near each smoke detector that may not be readily visible, and each sprinkler water-flow switch and valve-tamper switch. Light is connected to flash when the associated device is in an alarm or trouble mode. Lamp is flush mounted in a single gang wall plate. A red, laminated, phenolic-resin identification plate at the indicating light identifies, in engraved white letters, device initiating the signal and room where the smoke detector or valve is located. For water-flow switches, the identification plate also designates protected spaces downstream from the water-flow switch.

# 2.8 MAGNETIC DOOR HOLDERS

A. Provide wiring for magnetic door holders furnished and installed by the door hardware contractor.

## 2.9 PROGRAMMER/TESTOR

A. Provide a programmer/testor for any fire alarm system requiring such a device for programming and maintenance of signal initiation devices. Furnish unit complete with carrying case and instructions.

# 2.10 CENTRAL FACP

A. Cabinet: Lockable steel enclosure. Arrange interior components so operations required for testing or for normal maintenance of the system are performed from the front of the enclosure. If more than one unit is

required to form a complete control panel, fabricate with matching modular unit enclosure to accommodate components and to allow ample gutter space for field wiring and interconnecting panels.

- 1. Identify each enclosure with an engraved, red, laminated, phenolic-resin nameplate with lettering not less than 1 inch (25 mm) high. Identify individual components and modules within cabinets with permanent labels.
- 2. Mounting: Flush.
- B. Alarm and Supervisory Systems: Separate and independent in the FACP. Alarm-initiating zone boards consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.
- C. Control Modules: Include types and capacities required to perform all functions of fire alarm systems. Provide 20% spare signal capacity for future alarm devices.
- D. Indications: Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.
- E. Resetting Controls: Prevent the resetting of alarm, supervisory, or trouble signals while the alarm or trouble condition still exists.
- F. Alphanumeric Display and System Controls: Arranged for interface between human operator at the FACP and addressable system components, including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
  - 1. Display: Liquid-crystal type, 40 (small projects) or 80 (large projects) characters, minimum.
  - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- G. Alphanumeric Display and System Controls: Arranged for interface between human operator at the FACP and addressable system components, including annunciation, supervision, and control.
  - 1. Display: A minimum of 80 characters; alarm, supervisory, and component status messages; and indicate control commands to be entered into the system for control of smoke detector sensitivity and other parameters.
  - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- H. Instructions: Printed or typewritten instruction card mounted behind a plastic or glass cover in a stainlesssteel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

# 2.11 NOTIFICATION APPLIANCE CIRCUIT (NAC) EXTENDER PANELS

- A. Provide NAC panels as required to support notification appliances.
- B. Provide layout of proposed NAC panel locations prior to installation.

### 2.12 REMOTE ANNUNCIATOR

- A. Description: Duplicate annunciator functions of the FACP for alarm, supervisory, and trouble indications. Also duplicate manual switching functions of the FACP, including acknowledging, silencing, reset, and test.
  - 1. Mounting: Flush cabinet, NEMA 250, Class 1.
- B. Display Type and Functional Performance: Alphanumeric display same as the FACP. Controls with associated LEDs permit acknowledging, silencing, resetting, and testing functions for alarm, supervisory, and trouble signals identical to those in the FACP.

### 2.13 FIREFIGHTER'S SMOKE CONTROL STATION

- A. Firefighters Smoke Control Station (FSCS): shall provide full monitoring and manual control capability over all smoke-control/evacuation systems and equipment. The FSCS shall be furnished by the fire alarm system manufacturer. The FSCS shall have the highest priority control over all smoke-control systems and equipment and shall override or bypass other building controls such as Hand-Off-Auto switches and On-Off switches. The FSCS shall depict graphically the physical building arrangement, smoke-control systems and equipment and the areas served by the equipment. Provide all equipment required for complete operation of the smoke control system including but not limited to conduit, wire and interface devices. System shall include the following:
  - 1. Control panel shall be semi-flush mounting with a maximum panel width of 24 inches.
  - 2. Operable controls shall be placed behind a lockable see-through door.
  - 3. Graphic panel with pilot lamps and switches.
  - 4. Provide a pilot lamp test switch to test all lamps on the panel.
  - 5. All lamps shall be LED type.
  - 6. Panel shall be UL Listed as a Firefighters Smoke Control Station under UL864-UUKL for smoke control.
- B. Smoke Control System: Fans within the building shall be shown on the FSCS. A clear indication of the direction of the airflow and the relationship of the components shall be displayed. Status indicators shall be provided for all smoke control equipment, annunciated by fan and zone and by pilot lamp type indicators as follows:
  - 1. Fans, dampers, and other operating equipment in their normal status White.
  - 2. Fans, dampers, and other operating equipment in their off or closed status Red.
  - 3. Fans, dampers, and other operating equipment in their on or open status Green.
  - 4. Fans, dampers, and other operating equipment in a fault status Yellow/Amber.
- C. Features: The FSCS shall provide control capability over the complete smoke control system equipment within the building as follows:
  - 1. On-Auto-Off control over each individual piece of operating smoke control equipment that can also be controlled from other sources within the building. This includes stairway pressurization fans; smoke exhaust fans; supply, return and exhaust fans; elevator shaft fans; and other operating equipment used or intended for smoke control purposes.

- 2. Open-Auto-Close control over individual dampers related to smoke control and that are also controlled from other sources within the building.
- 3. On-Off or Open-Close control over smoke control and other critical equipment associated with a fire or smoke emergency and that can only be controlled from the FSCS.
- D. Acceptance Testing: Devices, equipment, components and sequences shall be individually tested. These tests shall consist of determination of function, sequence and capacity of their installed condition. Tests shall include:
  - 1. Detection devices.
  - 2. Ducts.
  - 3. Dampers.
  - 4. Inlet and outlets.
  - 5. Fans.
  - 6. Smoke barriers.
  - 7. Controls.
- E. Special Inspections for Smoke Control: Smoke control systems shall be tested by a third party, special inspector as part of this contract.
  - 1. Qualifications: Special inspection agencies for smoke control shall have experience in fire protection engineering, mechanical, engineering and certification as air balancers.
  - 2. Reports: A complete report of testing shall be provided by the special inspector. The report shall include identification of all devices by manufacturer, nameplate data, design values, measured values and identification tag or mark.
  - 3. Report Filing: A copy of the final report shall be filed with the fire code official and a copy shall be maintained in the building.

## 2.14 EMERGENCY POWER SUPPLY

- A. General: Components include lead acid battery, charger, and an automatic transfer switch.
  - 1. Battery Nominal Life Expectancy: 20 years, minimum.
- B. Battery Capacity: Comply with NFPA 72.
  - 1. Magnetic door holders are not served by emergency power. Magnetic door holders are released when normal power fails.
- C. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.
- D. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

### 2.15 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module listed for use in providing a multiplex system address for listed fire and sprinkler alarm-initiating devices with normally open contacts.

## 2.16 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Listed and labeled under UL 864 and NFPA 72.
- B. Functional Performance: Unit receives an alarm, supervisory, or trouble signal from the FACP panel, and automatically captures one or two telephone lines and dials a preset number for a remote central station. When contact is made with the central station(s), the signal is transmitted. The unit supervises up to two telephone lines. Where supervising two lines, if service on either line is interrupted for longer than 45 seconds, the unit initiates a local trouble signal and transmits a signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. When telephone service is restored, unit automatically reports that event to the central station. If service is lost on both telephone lines, the local trouble signal is initiated.
- C. Secondary Power: Integral rechargeable battery and automatic charger. Battery capacity is adequate to comply with NFPA 72 requirements.
- D. Self Test: Conducted automatically every 24 hours with report transmitted to central station.

## 2.17 GUARDS FOR PHYSICAL PROTECTION

- A. Description: Welded wire mesh of size and shape for the manual stations, smoke detectors, and audio/visual devices located in school gymnasiums, multi-purpose rooms and locker rooms.
  - 1. Factory fabricated and furnished by the manufacturer of the device.
  - 2. Finish: Paint of color to match the protected device.

#### 2.18 WIRE

- A. Non-Power-Limited Circuits: Copper conductors with 600-V rated, 75 deg C, color-coded insulation.
  - 1. Low-Voltage Circuits: No. 16 AWG, minimum.
  - 2. Line-Voltage Circuits: No. 12 AWG, minimum.
- B. Power-Limited Circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer.

# 2.19 BREAKER LOCK DEVICE

A. Provide breaker circuit lockout device on branch circuits feeding any fire alarm equipment including fire alarm panels and NAC panels. Utilize Elock fire alarm circuit lockout kit #ELOCK-FA and a red placard indicating "FIRE ALARM / EMERGENCY CIRCUIT INSIDE". PART 3 - EXECUTION

### 3.1 EQUIPMENT INSTALLATION

- A. Install fire alarm system in accordance with manufacturer's installation drawings and instructions.
- B. Connecting to Existing Equipment: Verify that existing fire alarm system is operational before making changes or connections.
  - 1. Connect new equipment to the existing control panel in the existing part of the building.
  - 2. Expand, modify, and supplement the existing control equipment as necessary to extend the existing control functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.
- C. Manual Pull Stations: Mount semiflush in recessed back boxes.
- D. Water-Flow Detectors and Valve Supervisory Switches: Connection for each sprinkler valve station required to be supervised.
- E. Ceiling-Mounted Smoke Detectors: Not less than 4 inches from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 30 feet apart in any direction.
- F. Wall-Mounted Smoke Detectors: At least 4 inches, but not more than 12 inches, below the ceiling.
- G. Smoke Detectors near Air Registers: Install no closer than 60 inches.
- H. Duct Smoke Detectors: Comply with manufacturer's written instructions.
  - 1. Verify that each unit is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
  - 2. Install sampling tubes so they extend the full width of the duct.
- I. Audible Alarm-Indicating Devices: Install chimes and horns on flush-mounted back boxes with the deviceoperating mechanism concealed behind a grille. Combine audible and visible alarms at the same location into a single unit.
- J. Visible Alarm-Indicating Devices: Install adjacent to each alarm chime or alarm horn.
- K. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- L. Horn/strobe at Fire Fighter's Hose Connection: Connect horn/strobe located on the exterior of the building associated with the sprinkler system.
- M. FACP: Surface mount with tops of cabinets not more than 72 inches above the finished floor.
- N. Annunciator: Install with the top of the panel not more than 60 inches above the finished floor.
- O. Provide smoke detectors where required for all FACP and NAC panels.

- P. Provide power to all FACP and NAC panels. Connect to emergency power when available.
- 3.2 WIRING INSTALLATION
  - A. Install wiring according to the following:
    - 1. NECA 1.
    - 2. TIA/EIA 568-A.
  - B. Wiring Method:
    - 1. Install wiring in raceways except in accessible ceiling spaces and in gypsum-board partitions where cable wiring method may be used. Route the fire alarm cable in cable tray system when available. Wiring run in ceiling space where there is no tray or conduit, support independently of other systems with dedicated low voltage rings / hooks.
    - 2. Conceal cables and raceways except in unfinished spaces.
    - 3. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
    - 4. Fire-Rated Cables: Use of 2-hour fire-rated fire alarm cables, NFPA 70 Types MI and CI, is not permitted.
    - 5. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.
  - C. Wiring Method: Fire alarm systems that interface with smoke control systems shall have all wiring, regardless of voltage, installed in continuous raceways.
  - D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by the manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
  - E. Cable Taps: Use numbered terminal strips in junction, pull and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
  - F. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
  - G. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signal from other floors.
  - H. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the FACP and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

I. Provide handle clamps on all circuit breakers feeding fire alarm system components. Handle clamps shall lock the circuit breaker in the "ON" position.

## 3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals according to Division 26 Section Identification for Electrical Systems."
- B. Install instructions frame in a location visible from the FACP.
- C. Install circuit breaker lockout kit and plackard on panels indicating where emergency fire alarm circuits are fed from.

### 3.4 GROUNDING

- A. Ground the FACP and associated circuits; comply with IEEE 1100. Install a #8 AWG ground wire from main service ground to the FACP.
- B. Ground cable shields and equipment according to system manufacturer's written instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.
- D. Install grounding electrodes of type, size, location, and quantity as indicated. Comply with installation requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Ground equipment and conductor and cable shields. For audio circuits, minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

#### 3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect fieldassembled components and connections and to supervise pretesting, testing, and adjustment of the system. Report results in writing.
- B. Pretesting: After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- C. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.

- D. Final Test Notice: Provide a minimum of 10 days' notice in writing when the system is ready for final acceptance testing.
- E. Minimum System Tests: Test the system according to procedures outlined in NFPA 72. Minimum required tests are as follows:
  - 1. Verify the absence of unwanted voltages between circuit conductors and ground.
  - 2. Test all conductors for short circuits using an insulation-testing device.
  - 3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record drawings.
  - 4. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
  - 5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
  - 6. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
  - 7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications.
  - 8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.
  - 9. Test smoke control operation startup and shutdown.
- F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets Specifications and complies with applicable standards.
- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.
- H. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.
- I. Provide certification of the fire alarm installation. Submit required documents to the Michigan Department of Labor & Economic Growth, Office of Fire Safety.

## 3.6 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

# 3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

- 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of 8 hours' training.
- 2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.
- 3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

### 3.8 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide onsite assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

## END OF SECTION 28 3100

### SECTION 31 1000 - SITE CLEARING

### PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Protecting existing vegetation to remain.
  - 2. Removing existing vegetation.
  - 3. Clearing and grubbing.
  - 4. Stripping and stockpiling topsoil.
  - 5. Removing above- and below-grade site improvements.
  - 6. Disconnecting, capping or sealing, and removing site utilities abandoning site utilities in place.
  - 7. Temporary erosion and sedimentation control.

## 1.3 DEFINITIONS

- A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.
- C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow.
- D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; and free of weeds, roots, toxic materials, or other nonsoil materials.
- E. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.
- F. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and indicated on Drawings.
- G. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

## 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

### 1.5 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

### 1.6 INFORMATIONAL SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
  - 1. Use sufficiently detailed photographs or video recordings.
  - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.
- B. Topsoil removal program.
- C. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.
- D. Burning: Is not permitted.

## 1.7 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
  - 2. Provide alternate routes around closed or obstructed trafficways if required by Owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
  - 1. Do not proceed with work on adjoining property until directed by Architect.
- C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises as directed.
- D. Utility Locator Service: Notify Miss Dig and Schoolcraft College for area where Project is located before site clearing.
- E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant protection measures are in place.

- F. Tree- and Plant-Protection Zones: Protect according to requirements as shown on plans.
- G. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."
  - 1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed.
- C. Protect existing site improvements to remain from damage during construction.
  - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

## 3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control drawings and requirements of authorities having jurisdiction.
- B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
- D. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

#### 3.3 TREE AND PLANT PROTECTION

- A. Protect trees and plants remaining on-site.
- B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 02111 "Landscape Preparation".

## 3.4 EXISTING UTILITIES

- A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
  - 1. Verify that utilities have been disconnected and capped before proceeding with site clearing.
- B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
  - 1. Arrange with utility companies to shut off indicated utilities.
  - 2. Owner will arrange to shut off indicated utilities when requested by Contractor.
- C. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
  - 1. Notify Owner not less than two days in advance of proposed utility interruptions.
  - 2. Do not proceed with utility interruptions without Architect's written permission.
- E. Excavate for and remove underground utilities indicated to be removed.
- F. Removal of underground utilities is included in earthwork sections.

# 3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
  - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
  - 2. Grind down stumps and remove roots larger than 2 inches in diameter, obstructions, and debris to a depth of 18 inches below exposed subgrade.
  - 3. Use only hand methods or air spade for grubbing within protection zones.
  - 4. Chip removed tree branches and dispose of off-site.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
  - 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

# 3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil in a manner to prevent intermingling with underlying subsoil or other waste materials.
  - 1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.

C. Dispose of topsoil.

#### 3.7 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
  - 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
  - Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

## 3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
- B. Burning tree, shrub, and other vegetation waste is not permitted.
- C. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials, and transport them to recycling facilities. Do not interfere with other Project work.

## END OF SECTION 31 1000
## SECTION 31 2000 - EARTH MOVING

### PART 1 - GENERAL

# 1.1 RELATED DOCUMENTS

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

# 1.2 SUMMARY

- A. Section Includes:
  - 1. Excavating and filling for rough grading the Site.
  - 2. Preparing subgrades for slabs-on-grade walks pavements turf and grasses and plants.
  - 3. Excavating and backfilling for buildings and structures.
  - 4. Drainage course for concrete slabs-on-grade.
  - 5. Subbase course for concrete walks.
  - 6. Subbase course and base course for asphalt paving.
  - 7. Subsurface drainage backfill for walls and trenches.
  - 8. Excavating and backfilling trenches for utilities and pits for buried utility structures.
- B. Related Requirements:
  - 1. Section 312319 "Dewatering" for lowering and disposing of ground water during construction.
  - 2. Section 02111 "Landscape Preparation" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.
  - 3. Owner's Geotechnical Evaluation Report for recommendations for site preparation, sub grade preparation for slabs, re-use of onsite soils as engineered fill, foundation design, seismic design and general construction considerations.

# 1.3 UNIT PRICES

- A. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials.
  - 1. 24 inches outside of concrete forms other than at footings.
  - 2. 12 inches outside of concrete forms at footings.
  - 3. 6 inches outside of minimum required dimensions of concrete cast against grade.
  - 4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
  - 5. 6 inches beneath bottom of concrete slabs-on-grade.
  - 6. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

# 1.4 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
  - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.

- 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
  - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
  - 2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
  - 3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. for bulk excavation or 3/4 cu. yd. for footing, trench, and pit excavation that cannot be removed by rock-excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
  - 1. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch maximum-width, short-tip-radius rock bucket; rated at not less than 138-hp flywheel power with bucket-curling force of not less than 28,700 lbf and stick-crowd force of not less than 18,400 lbf with extra-long reach boom.
  - 2. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-hp flywheel power and developing a minimum of 47,992-lbf breakout force with a general-purpose bare bucket.
- I. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. or more in volume that exceed a standard penetration resistance of 100 blows/2 inches when tested by a geotechnical testing agency, according to ASTM D 1586.
- J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- K. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

- L. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- M. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

# 1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct pre-excavation conference at project site.
  - 1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
    - a. Personnel and equipment needed to make progress and avoid delays.
    - b. Coordination of Work with utility locator service.
    - c. Coordination of Work and equipment movement with the locations of tree- and plantprotection zones.
    - d. Extent of trenching by hand or with air spade.
    - e. Field quality control.

# 1.6 ACTION SUBMITTALS

- A. Product Data: For each type of the following manufactured products required:
  - 1. Geotextiles and geogrids.
  - 2. Controlled low-strength material, including design mixture.
  - 3. Warning tapes.
- B. Samples for Verification: For the following products, in sizes indicated below:
  - 1. Geotextile and geogrids: 12 by 12 inches (300 by 300 mm).
  - 2. Warning Tape: 12 inches (300 mm) long; of each color.

# 1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
  - 1. Classification according to ASTM D 2487.
  - 2. Laboratory compaction curve according to ASTM D 698 or ASTM D 1557.
- C. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

### 1.8 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

- B. Codes and Standards: Perform earthwork complying with requirements of authorities having jurisdiction.
  - 1. Comply with State of Michigan, Department of Transportation (MDOT), 2012 Standard Specifications for Construction except as otherwise specified.

# 1.9 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
  - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
  - 1. Do not proceed with work on adjoining property until directed by Architect.
- C. Utility Locator Service: Notify Miss Dig for area where Project is located before beginning earth-moving operations.
- D. The following practices are prohibited within protection zones:
  - 1. Storage of construction materials, debris, or excavated material.
  - 2. Parking vehicles or equipment.
  - 3. Foot traffic.
  - 4. Erection of sheds or structures.
  - 5. Impoundment of water.
  - 6. Excavation or other digging unless otherwise indicated.
  - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- E. Do not direct vehicle or equipment exhaust towards protection zones.
- F. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

#### PART 2 - PRODUCTS

### 2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

- C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487 or a combination of these groups.
  - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 294/D 2940M 0; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.
- F. Aggregate Base Course Under Building Slabs-On-Grade to Receive Terrazzo Flooring: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone and natural or crushed sand complying with MDOT Table 9.02-2 for 21AA Dense Graded Aggregate.
- G. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve. Free of frozen soil, organics and other unsuitable materials.
- H. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
- I. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and zero to 5 percent passing a No. 8 sieve.
- J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and zero to 5 percent passing a No. 4 sieve.
- K. Sand: ASTM C 33/C 33M; fine aggregate.
- L. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

# PART 3 - EXECUTION

# 3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

# 3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
  - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

### 3.3 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
  - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
  - 2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
    - a. 24 inches outside of concrete forms other than at footings.
    - b. 12 inches outside of concrete forms at footings.
    - c. 6 inches outside of minimum required dimensions of concrete cast against grade.
    - d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
    - e. 6 inches beneath bottom of concrete slabs-on-grade.
    - f. 6 inches beneath pipe in trenches and the greater of 24 inches wider than pipe or 42 inches wide.
- B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.
  - 1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; and soil, boulders, and other materials not classified as rock or unauthorized excavation.
    - a. Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

- 2. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:
  - a. 24 inches outside of concrete forms other than at footings.
  - b. 12 inches outside of concrete forms at footings.
  - c. 6 inches outside of minimum required dimensions of concrete cast against grade.
  - d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
  - e. 6 inches beneath bottom of concrete slabs-on-grade.
  - f. 6 inches beneath pipe in trenches and the greater of 24 inches wider than pipe or 42 inches wide.

# 3.4 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. Site clearing shall extend a minimum of 5-feet beyond the limits of the proposed walls of the proposed improvements to ensure uniform support of proposed improvements. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
  - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
  - 2. Pile Foundations: Stop excavations 6 to 12 inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
  - Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.
- B. Excavations at Edges of Tree- and Plant-Protection Zones:
  - 1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

# 3.5 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

# 3.6 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
  - 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.
  - 1. Clearance: as indicated.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
  - 1. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
  - 2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
  - 3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
  - 4. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
- D. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
  - 1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

# 3.7 SUBGRADE INSPECTION

- A. Notify Architect when excavations have reached required subgrade.
- B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
  - 1. Completely proof-roll subgrade in one direction repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
  - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

# 3.8 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi (17.2 MPa), may be used when approved by Architect.
  - 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

# 3.9 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
  - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

# 3.10 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
  - 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
  - 2. Surveying locations of underground utilities for Record Documents.
  - 3. Testing and inspecting underground utilities.
  - 4. Removing concrete formwork.
  - 5. Removing trash and debris.
  - 6. Removing temporary shoring, bracing, and sheeting.
  - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

### 3.11 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Backfill voids with satisfactory soil while removing shoring and bracing.
- D. Initial Backfill:
  - 1. Soil Backfill: Place and compact initial backfill of subbase material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
    - a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

- 2. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.
- E. Final Backfill:
  - 1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
  - 2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.

# 3.12 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
  - 1. Under grass and planted areas, use satisfactory soil material.
  - 2. Under walks and pavements, use satisfactory soil material.
  - 3. Under steps and ramps, use engineered fill.
  - 4. Under building slabs including the soccer dome, use engineered fill.
  - 5. Under footings and foundations, use engineered fill.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

# 3.13 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
  - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
  - 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

# 3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in level layers not more than 9 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to Modified Proctor Test per ASTM D 698:
  - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and compact each layer of backfill or fill soil material at 95 percent.
  - 2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent.

- 3. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
- 4. For utility trenches, compact each layer of initial and final backfill soil material at 95 percent.

# 3.15 GRADING

- A. Subdrainage Pipe: as indicated.
- B. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
  - 1. Provide a smooth transition between adjacent existing grades and new grades.
  - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- C. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:
  - 1. Turf or Unpaved Areas: Plus or minus 1 inch.
  - 2. Walks: Plus or minus 1 inch.
  - 3. Pavements: Plus or minus  $\frac{1}{2}$  inch.
- D. Grading inside Building Lines: Finish subgrade to a tolerance of ½ inch when tested with a 10-foot straightedge.

# 3.16 SUBSURFACE DRAINAGE

- A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
  - 1. Compact each filter material layer to 95 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.
- B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
  - 1. Compact each filter material layer to 95 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.
  - 2. Place and compact impervious fill over drainage backfill in 6-inch- thick compacted layers to final subgrade.

#### 3.17 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course and base course on subgrades free of mud, frost, snow.
- B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:

- 1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
- 2. Place base course material over subbase course under hot-mix asphalt pavement.
- 3. Shape subbase course and base course to required crown elevations and cross-slope grades.
- 4. Place subbase course and base course 6 inches or less in compacted thickness in a single layer.
- 5. Place subbase course and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
- 6. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.
- C. Pavement Shoulders: Place shoulders along edges of subbase course and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

# 3.18 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place 21AA aggregate drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
  - 1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
  - 2. Place drainage course 6 inches or less in compacted thickness in a single layer.
  - 3. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
  - 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

# 3.19 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
  - 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
  - 2. Determine that fill material classification and maximum lift thickness comply with requirements.
  - 3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
  - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab but in no case fewer than three tests.
  - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length but no fewer than two tests.
  - 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length but no fewer than two tests.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

# 3.20 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
  - 1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
  - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

# 3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.
- B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.
  - 1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 2000

### **SECTION 31 2319 - DEWATERING**

### PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

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

# 1.2 SUMMARY

- A. Section includes construction dewatering.
- B. Related Requirements:
  - 1. Section 312000 "Earth Moving" for excavating, backfilling, site grading, and controlling surfacewater runoff and ponding.

# 1.3 ALLOWANCES

A. Dewatering observation wells are part of dewatering allowance.

## 1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at project site.
  - 1. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
  - 2. Review condition of site to be dewatered including coordination with temporary erosion-control measures and temporary controls and protections.
  - 3. Review geotechnical report.
  - 4. Review proposed site clearing and excavations.
  - 5. Review existing utilities and subsurface conditions.
  - 6. Review observation and monitoring of dewatering system.

# 1.5 ACTION SUBMITTALS

- A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.
  - 1. Include plans, elevations, sections, and details.
  - 2. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
  - 3. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
  - 4. Include written plan for dewatering operations including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.

### 1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For installer.
- B. Field quality-control reports.
- C. Existing Conditions: Using video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by dewatering operations. Submit before Work begins.
- D. Record Drawings: Identify locations and depths of capped wells and well points and other abandoned-inplace dewatering equipment.

### 1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.

### 1.8 FIELD CONDITIONS

- A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.
  - 1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.
  - 2. The geotechnical report is included elsewhere in Project Manual.
- B. Survey Work: Engage a qualified registered land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

#### PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
  - 1. Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer.
  - Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
  - 3. Prevent surface water from entering excavations by grading, dikes, or other means.
  - 4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.

- 5. Remove dewatering system when no longer required for construction.
- B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water- and debris-disposal regulations of authorities having jurisdiction.

### PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
  - 1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.
  - 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- C. Provide temporary grading to facilitate dewatering and control of surface water.
- D. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 311000 "Site Clearing," during dewatering operations.

# 3.2 INSTALLATION

- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
  - 1. Space well points or wells at intervals required to provide sufficient dewatering.
  - 2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
- B. Place dewatering system into operation to lower water to specified levels before excavating below groundwater level.
- C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
- D. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

# 3.3 OPERATION

A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

- B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
  - 1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
  - 2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
  - 3. Maintain piezometric water level a minimum of 24 inches below bottom of excavation.
- C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.
- D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches (900 mm) below overlying construction.

# 3.4 FIELD QUALITY CONTROL

- A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.
  - 1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
  - 2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
  - 3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.
- B. Survey-Work Benchmarks: Resurvey benchmarks regularly during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.
- C. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.
- D. Prepare reports of observations.

# 3.5 PROTECTION

- A. Protect and maintain dewatering system during dewatering operations.
- B. Promptly repair damages to adjacent facilities caused by dewatering.

# END OF SECTION 31 2319

DEWATERING 31 2319 - 5 10/24/2019

## SECTION 32 1216 - ASPHALT PAVING

### PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

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

# 1.2 SUMMARY

- A. Section Includes:
  - 1. Hot-mix asphalt paving.
- B. Related Requirements:
  - 1. Section 311000 "Site Clearing" for demolition and removal of existing asphalt pavement.
  - 2. Section 312000 "Earth Moving" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.

### 1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at project site.
  - 1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
    - a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
    - b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

# 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include technical data and tested physical and performance properties.
  - 2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
  - 3. Job-Mix Designs: For each job mix proposed for the Work.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Material Certificates: For each paving material.
- B. Material Test Reports: For each paving material, by a qualified testing agency.
- C. Field quality-control reports.

## 1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or MDOT.
- B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.
- C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of MDOT for asphalt paving work.
  - 1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

### 1.7 FIELD CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
  - 1. Prime Coat: Minimum surface temperature of 60 deg F.
  - 2. Tack Coat: Minimum surface temperature of 60 deg F.
  - 3. Slurry Coat: Comply with weather limitations in ASTM D 3910.
  - 4. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
  - 5. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

#### PART 2 - PRODUCTS

#### 2.1 AGGREGATES

- A. Coarse Aggregate: MDOT 21AA, sound; angular crushed stone, crushed gravel.
- B. Fine Aggregate: MDOT 3F3 or 3CS, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
  - 1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.
- C. Mineral Filler: MDOT 3MF, rock or slag dust, hydraulic cement, or other inert material.

#### 2.2 ASPHALT MATERIALS

- A. Asphalt Cement: MDOT (Penetration Grade) 85-100.
- B. Tack Coat: MDOT RC 70 emulsified asphalt, or MDOT SS-1h cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
- C. Water: Potable.

# PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Verify that subgrade is dry and in suitable condition to begin paving.
- B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
  - 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
  - 2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
  - 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.

# 3.2 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
- B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
  - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
  - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

# 3.3 PLACING HOT-MIX ASPHALT

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
  - 1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
  - 2. Place hot-mix asphalt surface course in single lift.
  - 3. Spread mix at a minimum temperature of 250 deg F.
  - 4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
  - 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
  - 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.
  - 2. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

# 3.4 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
  - 1. Clean contact surfaces and apply tack coat to joints.
  - 2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
  - 3. Offset transverse joints, in successive courses, a minimum of 24 inches.
  - 4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
  - 5. Compact asphalt at joints to a density within 2 percent of specified course density.

# 3.5 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
  - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
  - 1. Average Density: 96 percent of reference laboratory density according to AASHTO T 245, but not less than 94 percent or greater than 100 percent.
  - 2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

## 3.6 INSTALLATION TOLERANCES

- A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
  - 1. Base Course: Plus or minus 1/2 inch.
  - 2. Surface Course: Plus 1/4 inch, no minus.
- B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
  - 1. Base Course: 1/4 inch.
  - 2. Surface Course: 1/8 inch.
  - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

### 3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
- C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement.
  - 1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
  - In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
    - a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than three cores taken.
    - b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- E. Replace and compact hot-mix asphalt where core tests were taken.
- F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

# END OF SECTION 32 1216

### SECTION 32 1313 - CONCRETE PAVING

#### PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. Section Includes Concrete Paving Including the Following:
  - 1. Curbs and walks.
  - 2. Walks.
- B. Related Requirements:
  - 1. Section 321723 "Pavement Markings."
  - 2. Section 321726 "Tactile Warning Surfacing" for detectable warning mats.

### 1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.
- B. W/C Ratio: The ratio by weight of water to cementitious materials.

### 1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at project sites.
  - 1. Review methods and procedures related to concrete paving, including but not limited to, the following:
    - a. Concrete mixture design.
    - b. Quality control of concrete materials and concrete paving construction practices.
  - 2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
    - a. Contractor's superintendent.
    - b. Independent testing agency responsible for concrete design mixtures.
    - c. Ready-mix concrete manufacturer.
    - d. Concrete paving Subcontractor.
    - e. Manufacturer's representative of stamped concrete paving system used for stamped detectable warnings.

### 1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.
- C. Samples for Verification: For each type of product or exposed finish, prepared as Samples of size indicated below:
  - 1. Exposed Aggregate: 10 lb Sample of each mix.
- D. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

## 1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified ready-mix concrete manufacturer and testing agency.
- B. Material Certificates: For the following, from manufacturer:
  - 1. Cementitious materials.
  - 2. Steel reinforcement and reinforcement accessories.
  - 3. Fiber reinforcement.
  - 4. Admixtures.
  - 5. Curing compounds.
  - 6. Applied finish materials.
  - 7. Bonding agent or epoxy adhesive.
  - 8. Joint fillers.
  - 9. Aggregates.
- C. Field quality-control reports.

#### 1.7 QUALITY ASSURANCE

- A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
  - 1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual Section 3, "Plant Certification Checklist").
- B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
  - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

## 1.8 **PRECONSTRUCTION TESTING**

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

# 1.9 FIELD CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
  - 1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
  - 2. Do not use frozen materials or materials containing ice or snow.
  - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
- C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
  - 1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
  - 2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
  - 3. Fog-spray forms[, steel reinforcement,] and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

# PART 2 - PRODUCTS

# 2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 unless otherwise indicated.

#### 2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
  - 1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

### 2.3 STEEL REINFORCEMENT

- A. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, fabricated galvanized steel wire into flat sheets.
- B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.
- C. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 plain-steel bars. Cut bars true to length with ends square and free of burrs.
- D. Tie Bars: ASTM A 615/A 615M, Grade 60; deformed.
- E. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- F. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
  - 1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
  - 2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

# 2.4 CONCRETE MATERIALS

- A. Portland Cement Concrete:
  - 1. The slump for concrete to be used for curb and gutter construction shall be 0-3 inches. For flatwork (e.g., sidewalks, drive approaches) the slump shall be 2-4 inches.
  - 2. Class A concrete shall consist of Portland cement, coarse aggregate (6AA limestone), fine aggregates, and water, proportioned with 564 lbs. cement (6 sacks) per cubic yard to produce a minimum 28 day compressive strength of 4000 psi, conforming to MDOT Sec. 7.01, Grade 35P. When used above ground, the air-cement ratio, by weight, may not exceed 0.45 for air entrained concrete, or 0.50 for non-air entrained concrete.
  - 3. Class A High Early Strength concrete shall be the same as Class A concrete except cement mixture shall be 846 lbs. (9 sack) per cubic yard conforming to MDOT Section 7.03, Concrete Repair Mixture Type P-MS. Chloride shall be added only as directed by the City.
- B. Air-Entraining Admixture: ASTM C 260/C 260M.
- C. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
- D. Water: Potable and complying with ASTM C 94/C 94M.

### 2.5 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
- B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.
- D. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.
- F. White, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B, dissipating.

# 2.6 RELATED MATERIALS

- A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber in preformed strips.
- B. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.
- C. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- D. Epoxy-Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:
- E. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch.

# 2.7 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
  - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
  - 2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.
- B. Cementitious Materials:
  - 1. Fly Ash or Pozzolan: 25 percent.
  - 2. Slag Cement: 50 percent.

- 3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.
- 4. Add air-entraining admixture at manufacturer's prescribed rate.
- C. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
- D. Concrete Mixtures: Normal-weight concrete.
  - 1. Compressive Strength (28 Days).
  - 2. Maximum W/C Ratio at Point of Placement: as prescribed.
  - 3. Slump Limit: as perscribed.

## 2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
  - 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
  - 1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
  - 2. For concrete batches larger than 1 cu. yd. increase mixing time by 15 seconds for each additional 1 cu. yd..
  - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

## PART 3 - EXECUTION

# 3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
  - 1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
  - 2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
  - 3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 312000 "Earth Moving."

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

### 3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

### 3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

### 3.4 STEEL REINFORCEMENT INSTALLATION

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

#### 3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
  - 1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
  - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
  - 2. Provide tie bars at sides of paving strips where indicated.
  - 3. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
  - 4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.

- 5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
  - 1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
  - 2. Extend joint fillers full width and depth of joint.
  - 3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
  - 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
  - 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
  - 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent concrete paving:
  - 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
    - a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.
  - 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
    - a. Tolerance: Ensure that sawed joints are within 3 inches either way from centers of dowels.
  - Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

# 3.6 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
  - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels and joint devices.
- H. Screed paving surface with a straightedge and strike off.
- I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.
- K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
  - 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

# 3.7 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
  - 1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
  - 2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
  - 3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

## 3.8 DETECTABLE WARNING INSTALLATION

A. Cast-in-Place Detectable Warning Tiles: Form blockouts in concrete for installation of tiles specified in Section 321726 "Tactile Warning Surfacing." Screed surface of concrete where tiles are to be installed to elevation, so that edges of installed tiles will be flush with surrounding concrete paving. Embed tiles in fresh concrete to comply with Section 321726 "Tactile Warning Surfacing" immediately after screeding concrete surface.

# 3.9 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound or a combination of these as follows:
  - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
    - a. Water.
    - b. Continuous water-fog spray.
    - c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
  - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period, using cover material and waterproof tape.
  - 3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

#### 3.10 PAVING TOLERANCES

- A. Comply with tolerances in ACI 117 and as follows:
  - 1. Elevation: 3/4 inch.
  - 2. Thickness: Plus 3/8 inch, minus 1/4 inch.
  - 3. Surface: Gap below 10-feet- long; unleveled straightedge not to exceed 1/2 inch.
  - 4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.

- 5. Lateral Alignment and Spacing of Dowels: 1 inch.
- 6. Vertical Alignment of Dowels: 1/4 inch.
- 7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
- 8. Joint Spacing: 3 inches.
- 9. Contraction Joint Depth: Plus 1/4 inch, no minus.
- 10. Joint Width: Plus 1/8 inch, no minus.

### 3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:
  - 1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. 5000 sq. ft. or fraction thereof of each concrete mixture placed each day.
    - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
  - 2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
  - 3. Air Content: ASTM C 231/C 231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
  - 4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
  - 5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
  - Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
    - a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressivestrength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
- D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

- F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
- G. Concrete paving will be considered defective if it does not pass tests and inspections.
- H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- I. Prepare test and inspection reports.

## 3.12 REPAIR AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.
- C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

# END OF SECTION 32 1313
# SECTION 32 1373 - CONCRETE PAVING JOINT SEALANTS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Expansion and contraction joints within cement concrete pavement.
  - 2. Joints between cement concrete and asphalt pavement.
- B. Related Sections include the following:
  - 1. Division 07 Section "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.
  - 2. Division 32 Section "Asphalt Paving" for constructing joints between concrete and asphalt pavement.
  - 3. Division 32 Section "Concrete Paving" for constructing joints in concrete pavement.

## 1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Product certificates.

#### 1.3 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

#### 1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration date, pot life, curing time, and mixing instructions for multicomponent materials.
- B. Store and handle materials to comply with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

#### 1.5 PROJECT CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
  - 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F(4.4 deg C).
  - 2. When joint substrates are wet or covered with frost.

- 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
- 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

#### PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products listed in other Part 2 articles.

#### 2.2 MATERIALS, GENERAL

- A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.
  - 1. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

#### 2.3 COLD-APPLIED JOINT SEALANTS

- A. Type SL Silicone Sealant for Concrete and Asphalt: Single-component, low-modulus, neutral-curing, selfleveling silicone sealant complying with ASTM D 5893 for Type SL.
  - 1. Products:
    - a. Crafco Inc.; RoadSaver Silicone SL.
    - b. Dow Corning Corporation; 890-SL.

## 2.4 JOINT-SEALANT BACKER MATERIALS

- A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.
- B. Round Backer Rods for Cold- and Hot-Applied Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.
- B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience.
- C. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- D. Install backer materials to support sealants during application and at position required to produce optimum sealant movement capability. Do not leave gaps between ends of backer materials. Do not stretch, twist, puncture, or tear backer materials. Remove absorbent backer materials that have become wet before sealant application and replace them with dry materials.
- E. Install sealants at the same time backings are installed to completely fill recesses provided for each joint configuration and to produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved by manufacturers of joint sealants and of products in which joints occur.

## 3.2 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations with repaired areas are indistinguishable from the original work.

## END OF SECTION 32 1373

#### SECTION 32 1723 - PAVEMENT MARKINGS

#### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

A. Section includes painted markings applied to asphalt and concrete pavement.

## 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at project site.

Review methods and procedures related to marking pavement including, but not limited to, the following:

- 1. Pavement aging period before application of pavement markings
- 2. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

## 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product Include technical data and tested physical and performance properties.
- B. Shop Drawings: For pavement markings.

Indicate pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

#### 1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of MDOT Standard Specifications For Construction, current edition, for pavement-marking work.

Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

#### 1.6 FIELD CONDITIONS

A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for alkyd materials 55 deg F for water-based materials, and not exceeding 95 deg F.

#### PART 2 - PRODUCTS

#### 2.1 PAVEMENT-MARKING PAINT

- A. General: Lines shall be painted with approved traffic paint compatible with bituminous surfaces.
- B. Parking Stalls and Hatched Areas: Aexcel; Regular-Dry Waterborne Traffic Marking Paint or equal product approved by Owner. Color: lead-free yellow.
- C. Handicapped-related Lines / Lettering / Symbols: Aexcel; Fast-Dry Waterborne Traffic Marking Paint or equal product approved by Owner. Color: blue
- D. Main Drive Lane Roadway Lines, Arrows, and Lettering: Aexcel; Hi-Performance Jet-Dry Waterborne Traffic Marking Paint or equal product approved by Owner. Color: lead-free yellow.
- E. Crosswalks: Shall be painted with 12-inch wide, solid painted lines accurately and neatly arranged as shown on the drawings. Color shall be white.

The pavement marking materials shall be applied in accordance to Table 811-1 from the 2012 MDOT Standard Specifications for Construction. Note the amount of material is shown per lane mile and should be converted to linear feet. (e.g. 12 inch solid waterborne 384lb/mile ÷ 5,280lf/mile = 0.073 lb/foot.) The application rate shall be verified by the contractor by applying a test section for the owner to review and accept before continuing with the remaining application

Table 811-1										
Pavement Marking Material Application Rates per Mile (a, b)										
		Binder	Line Type							
		volume &	Broken				Solid			
	Thickness	Bead								
Binder Type	(mil)	weight	4 in	6 in	8 in	12 in	4 in	6 in	8 in	12 in
Waterborne	15	Binder (gal)	4	6	8	12	16	24	32	48
		Bead (lb)	32	48	64	96	128	192	256	384
Low Temperature Waterborne	15	Binder (gal)	4	6	8	12	16	24	32	48
		Bead (lb)	32	48	64	96	128	192	256	384
Regular Dry	15	Binder (gal)	4	6	8	12	16	24	32	48
		Bead (lb)	24	36	48	72	96	144	192	288
Thermoplastic	90	Binder (lb)	435	653	870	1,305	1,740	2,610	3,480	5,220
		Bead (lb)	50	75	100	150	200	300	400	600
Sprayable Thermoplastic	30 (c)	Binder (lb)	140	210	280	420	560	840	1,120	1,680
		Bead (lb)	50	75	100	150	200	300	400	600
Polyurea	20	Binder (gal)	6	8	11	17	22	33	44	66
		Bead (lb)	As directed by the manufacturer							
a. Binder yield indicates the amount to produce the required mil thickness without drop on beads.										
b. Bead yield indicates the amount of drop on beads required for the given binder.										
c. Apply drop on beads for a final thickness of 40 mil.										

Sharp Silica Sand: Sharp silica sand used for bike lane symbols and pedestrian crosswalk lines shall meet the following gradation requirements:

Table 920-0: Silicia Sand Requirements						
Sieve Size	% Passing					
20	100					
50	0 to 10					

## PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Verify that pavement is dry and in suitable condition to begin pavement marking according to manufacturer's written instructions.
- B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

#### 3.2 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
- B. Allow paving to age for a minimum of 10 days before starting pavement marking.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to pavement. Mask an extended area beyond edges of each stencil to prevent paint application beyond the stencil. Apply paint so that it cannot run beneath the stencil.

#### 3.3 PROTECTING AND CLEANING

- A. Protect pavement markings from damage and wear during remainder of construction period.
- B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

# END OF SECTION 32 1723

## SECTION 32 1726 - TACTILE WARNING SURFACING

#### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Cast-in-place detectable warning tiles.
- B. Related Requirements:
  - 1. Section 321313 "Concrete Paving" for concrete walkways serving as substrates for tactile warning surfacing.

## 1.3 ACTION SUBMITTALS

- A. Product Data: Armor Tile Tactile System as manufactured by Engineered Plastics, Inc.
- B. Color: Brick Red #22144
- C. Samples for Verification: For each type of tactile warning surface, in manufacturer's standard sizes unless otherwise indicated, showing edge condition, truncated-dome pattern, texture, color, and cross section; with fasteners and anchors.

## 1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For tactile warning surfacing, to include in maintenance manuals.

#### 1.5 QUALITY ASSURANCE

- A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
  - 1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

#### 1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at project site.

#### 1.7 PROJECT CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.
- B. Weather Limitations for Adhesive Application:
  - 1. Apply adhesive only when ambient temperature is above 50 deg F and when temperature has not been below 35 deg F for 12 hours immediately before application. Do not apply when substrate is wet or contains excess moisture.
- C. Weather Limitations for Mortar and Grout:
  - 1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
  - 2. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602. Provide artificial shade and windbreaks, and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 deg F and higher.
    - a. When ambient temperature exceeds 100 deg F, or when wind velocity exceeds 8 mph and ambient temperature exceeds 90 deg F, set unit pavers within 1 minute of spreading setting-bed mortar.

#### 1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of tactile warning surfaces that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Deterioration of finishes beyond normal weathering and wear.
    - b. Separation or delamination of materials and components.
  - 2. Warranty Period: Five years from date of Substantial Completion.

## PART 2 - PRODUCTS

## 2.1 TACTILE WARNING SURFACING, GENERAL

- A. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1 for tactile warning surfaces.
  - 1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

## 2.2 DETECTABLE WARNING TILES

- A. Cast-in-Place Detectable Warning Tiles: Accessible truncated-dome detectable warning tiles with replaceable surface configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.
  - 1. Armor Tile Tactile System as manufactured by Engineered Plastics, Inc.
  - 2. Material: Molded glass- and carbon-fiber-reinforced polyester.
  - 3. Color: Red brick #22144
  - 4. Mounting: Per Manufactures guidelines.

## PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions. Verify that installation of tactile warning surfacing will comply with accessibility requirements upon completion.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.2 INSTALLATION OF TACTILE WARNING SURFACING, GENERAL

- A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.
- B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

# 3.3 INSTALLATION OF DETECTABLE WARNING TILES

- A. Cast-in-Place Detectable Warning Tiles:
  - 1. Concrete Paving Installation: Comply with installation requirements in Section 321313 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of tile.
  - 2. Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
  - 3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8 inch from flush.
  - 4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
  - 5. Clean tiles using methods recommended in writing by manufacturer.

# 3.4 CLEANING AND PROTECTION

- A. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.
- B. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

# END OF SECTION 32 1726

#### SECTION 33 1000 - WATER DISTRIBUTION

#### 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.
- B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

#### 1.3 ACTION 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.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For piping and specialties from manufacturers.
- B. Field quality-control test reports.

## 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

#### 1.6 QUALITY ASSURANCE

- A. Regulatory Requirements:
  - 1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
  - 2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
  - 3. 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. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

## 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.

## 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 Owner no fewer than two days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of water-distribution service without Owner's written permission.

## 1.9 COORDINATION

A. Coordinate connection to water main with utility company.

## PART 2 - PRODUCTS

## 2.1 COPPER TUBE AND FITTINGS

- A. Soft Copper Tube: ASTM B 88, Type K, water tube, annealed temper.
  - 1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
  - 2. Copper, Pressure-Seal Fittings:

- a. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
- b. NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
- B. Hard Copper Tube: ASTM B 88, Type K, water tube, drawn temper.
  - 1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
  - 2. Copper, Pressure-Seal Fittings:
    - a. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
    - b. NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
- C. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
- D. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-tometal seating surfaces, and solder-joint or threaded ends.

# 2.2 DUCTILE-IRON PIPE AND FITTINGS

- A. Joints All ductile iron water pipe and fittings shall have push-on joints either "Tyton" or "Super Bell Tite", except where otherwise noted.
- B. Fittings shall be Tyler Union or approved equal ductile iron with push-on joints, pressure rating 250 psi, conforming to ANSI Specification 21.10 (AWWA C110) "Gray Iron and Ductile-Iron Fittings", 2" through 48", for water and other liquids.

## 2.3 SPECIAL PIPE FITTINGS

- A. All horizontal and vertical bends require the use of "Mega-Lug" restraints and thrust blocking.
- B. All bolts must be "Cor-Blue" T-Bolt Type.

## 2.4 CORROSION-PROTECTION PIPING ENCASEMENT

A. All ductile iron water pipe shall be wrapped in 8 mil thick, black, polyethylene, in accordance with ANSI Spec. A-21.5.

## 2.5 GATE VALVES

A. Valves shall be manufactured and tested to meet the requirements of ANSI/AWWA C515. Valves shall meet or exceed the requirements of Underwriters Laboratories Standard C515. Valves shall meet or exceed the requirements of Underwrites Laboratories Standard UL262 and Factory Mutual Standard 1130 with a working pressure of the valve at 250 psi. Valves shall be per City of Farmington Hills / Oakland County Water Resources Commission.

# 2.6 GATE VALVE ACCESSORIES AND SPECIALTIES

- A. Tapping-Sleeve Assemblies:
  - 1. 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, metal-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, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 inches in diameter.
  - 1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

# 2.7 CORPORATION VALVES AND CURB VALVES

- A. Manufacturers:
  - 1. As approved by City/County.
- B. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.
  - 1. Service Saddle: Copper alloy 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 3 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.

## 2.8 WATER METERS

A. Water meters will be furnished by utility company.

## 2.9 CONCRETE VAULTS

- A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857 and made according to ASTM C 858.
  - 1. Ladder: ASTM A 36/A 36M, steel or polyethylene-encased steel steps.
  - 2. Manhole: ASTM A 48/A 48M Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.
    - a. Dimension: 48-inch minimum diameter, unless otherwise indicated.
  - 3. Manhole: ASTM A 536, Grade 60-40-18, ductile-iron traffic frame and cover.
    - a. Dimension: 48-inch minimum diameter, unless otherwise indicated.

# 2.10 FREE STANDING FIRE HYDRANTS

- 1. Per City of Farmington Hills / Oakland County Water Resources Commission.
  - a. Exterior Finish: Red alkyd-gloss enamel paint for public hydrants.
  - b. Pressure Rating: 150 psig minimum.
- 2. Description: Freestanding, with one NPS 4-1/2 and two NPS 2-1/2 outlets, NPS 6 threaded or flanged inlet, and base section with NPS 6 mechanical-joint inlet.

# PART 3 - EXECUTION

## 3.1 EARTHWORK

A. Refer to Section 31 2000 "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. Underground water-service piping NPS 3/4 to NPS 3 shall be the following:
  - 1. Soft copper tube, ASTM B 88, Type K.
- F. Underground Water-Service and Fire-Service-Main Piping NPS 4 to NPS 12 shall be the following:
  - 1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings.

#### 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. Use UL/FMG nonrising-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.

#### 3.4 PIPING INSTALLATION

- A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.
  - 1. Operating Valves The City of Farmington Hills Water Department will open and close all valves on existing lines. No valve on an existing water line is to be operated by anyone other than an authorized Water Department employee.
- B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.
- C. Make connections larger than NPS 2 with tapping machine according to the following:
  - 1. Install tapping sleeve and tapping valve according to MSS SP-60.
  - 2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
  - 3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
  - 4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
- D. 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 required by utility company standards.
  - 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.
- E. 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."
- F. 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.

- G. Bury piping with depth of cover over top at least five and a half feet.
- H. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
- I. 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 at 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.

#### 3.5 JOINT CONSTRUCTION

- A. Make pipe joints according to the following:
  - 1. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.
  - 2. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
  - 3. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
  - 4. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductileiron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.

#### 3.6 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

## 3.7 FIELD QUALITY CONTROL

- A. Connections to the existing water mains will not be allowed until the new lines have been passed the pressure test (150 p.s.i. for 1 hour max. loss 50 gal/inch dia,/mile/day) and have been satisfactorily disinfected with chlorine (50 ppm-24 hrs).
- B. Notifications Both the City of Farmington Hills Engineering Division and the City of Detroit Water and Sewer Department must be notified at least 24 hours in advance when any connections are to be made to an existing water main. "24 hours notification required"
- C. When a pressure test is to be made on a new water line, the City of Farmington Hills Engineering Department must be notified 24 hours in advance and be present for the test to verify that all main valves are open an to open all hydrants during the course of the pressure test. The contractor is responsible to provide the necessary equipment and labor to perform this test and is responsible to provide testing for bacteriologic water samples by an approved Michigan Department of Environmental Quality (MDEQ) certified lab. A hard copy of the approved results shall be provided to the City of Farmington Hills Engineering Division and the DPW before the scheduled connection to the main line occurs, along with proper (24 hours) notification to residents and businesses.

D. Final Verification – When all connections have been made following chlorination and pressure test, the contractor shall notify the City of Farmington Hills Water & Engineering Departments, so that they can verify that all valves are left in "OPEN" position.

# 3.8 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground waterdistribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."

#### 3.9 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
  - 1. Foam Swabbing (POLYPIG) Both the initial flushing and the flushing after chlorination will be supplemented by passing foam swab through the water main. The contractor shall be responsible for providing the required foam swab and provide a detailed plan prior to flushing.
  - 2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described by Detroit Water and Sewer Department for testing and flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
  - 3. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.

## END OF SECTION 33 1000

#### SECTION 33 3000 - SANITARY SEWERS

#### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Pipe and fittings.
  - 2. Cleanouts.
  - 3. Manholes.

#### 1.3 ACTION SUBMITTALS

A. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

## 1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of pipe and fitting, from manufacturer.
- B. Field quality-control reports.

#### 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. Interruption of Existing Sanitary Sewerage 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 service according to requirements indicated:
  - 1. Notify Owner no fewer than two days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of service without Owner's written permission.

#### PART 2 - PRODUCTS

#### 2.1 PVC PIPE AND FITTINGS

- A. PVC Cellular-Core Sewer Piping:
  - 1. Pipe: ASTM F 891, Sewer and Drain Series, PS 50 minimum stiffness, PVC cellular-core pipe with plain ends for solvent-cemented joints.
  - 2. Fittings: ASTM D 3034, SDR 35, PVC socket-type fittings.
- B. PVC Type PSM Sewer Piping:
  - 1. Pipe: ASTM D 3034, SDR 23.5, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
  - 2. Fittings: ASTM D 3034, PVC with bell ends.
  - 3. Gaskets: ASTM F 477, elastomeric seals.

# 2.2 CLEANOUTS

- A. PVC Cleanouts:
  - 1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

## 2.3 MANHOLES

- A. Standard Precast Concrete Manholes:
  - 1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
  - 2. Diameter: 48 inches minimum unless otherwise indicated.
  - 3. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
  - 4. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section; with separate base slab or base section with integral floor.
  - 5. Riser Sections: 4-inch minimum thickness, of length to provide depth indicated.
  - 6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated; with top of cone of size that matches grade rings.
  - 7. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
  - 8. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
  - 9. Steps: Individual FRP steps wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
  - 10. Adjusting Rings: Interlocking rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

- 11. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.
- B. Manhole Frames and Covers:
  - Description: Ferrous; per City of Farmington Hills / Oakland County Water Resources Commission. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
  - 2. Material: ASTM A 536, Grade 60-40-18 ductile iron unless otherwise indicated.

# 2.4 CONCRETE

- A. General: Cast-in-place concrete complying with ACI 318, ACI 350/350R, and the following:
  - 1. Cement: ASTM C 150, Type II.
  - 2. Fine Aggregate: ASTM C 33, sand.
  - 3. Coarse Aggregate: ASTM C 33, crushed gravel.
  - 4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
  - 1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
  - 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.
- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
  - 1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
    - a. Invert Slope: 1 percent through manhole.
  - 2. Benches: Concrete, sloped to drain into channel.
    - a. Slope: 4 percent.
- D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.
  - 1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
  - 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

# PART 3 - EXECUTION

# 3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

#### 3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
- F. Install gravity-flow, nonpressure, drainage piping according to the following:
  - 1. Install piping pitched down in direction of flow.
- G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Swab end of pipe.

## 3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure, drainage piping according to the following:
  - 1. Join PVC cellular-core sewer piping according to ASTM D 2321 and ASTM F 891 for solventcemented joints.

## 3.4 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Form continuous concrete channels and benches between inlets and outlet.
- D. Install manhole-cover inserts in frame and immediately below cover.

# 3.5 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

B. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

#### 3.6 CONNECTIONS

- A. Make connections to existing piping and underground manholes.
  - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch overlap with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
  - Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
  - 3. Make branch connections from side into existing piping, NPS 21 or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
    - a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.
    - b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
  - 4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

# 3.7 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
  - 1. Submit separate report for each system inspection.
  - 2. Defects requiring correction include the following:
    - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    - d. Infiltration: Water leakage into piping.
    - e. Exfiltration: Water leakage from or around piping.
  - 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
  - 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

- 1. Do not enclose, cover, or put into service before inspection and approval.
- 2. Test completed piping systems according to requirements of authorities having jurisdiction.
- 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
- 4. Submit separate report for each test.
- 5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
  - a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.
  - b. Close openings in system and fill with water.
  - c. Purge air and refill with water.
  - d. Disconnect water supply.
  - e. Test and inspect joints for leaks.
- 6. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction:
- 7. Manholes: Perform hydraulic test according to ASTM C 969
- C. Leaks and loss in test pressure constitute defects that must be repaired.
- D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

#### 3.8 CLEANING

A. Clean dirt and superfluous material from interior of piping, flush with potable water.

## END OF SECTION 33 3000

## SECTION 33 4100 - STORM DRAINAGE

#### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Pipe and fittings.
  - 2. Manholes.
  - 3. Catch basins.
  - 4. Pipe outlets.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
  - 1. Manholes: Include plans, elevations, sections, details, frames, and covers.
  - 2. Catch basins, stormwater inlets and dry wells. Include plans, elevations, sections, details, frames, covers, and grates.
  - 3. Stormwater Treatment Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of pipe and fitting, from manufacturer.
- B. Field quality-control reports.

#### 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.
- D. Handle catch basins and stormwater inlets according to manufacturer's written rigging instructions.

## 1.6 PROJECT CONDITIONS

- A. Interruption of Existing Storm Drainage 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 service according to requirements indicated:
  - 1. Notify Owner no fewer than two days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of service without Owner's written permission.

# PART 2 - PRODUCTS

# 2.1 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C76, with groove and tongue ends and gasketed joints with **ASTM C 443**, rubber gaskets, Class IV.

## 2.2 PVC PIPE AND FITTINGS

- A. PVC Gravity Sewer Piping:
  - 1. Pipe and Fittings: ASTM F 679, T-1 wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.

# 2.3 CLEANOUTS

- A. Plastic Cleanouts:
  - 1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

# 2.4 MANHOLES

- A. Standard Precast Concrete Manholes:
  - 1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
  - 2. Diameter: 48 inches minimum unless otherwise indicated.
  - 3. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
  - 4. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
  - 5. Riser Sections: 4-inch minimum thickness, and lengths to provide depth indicated.
  - 6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
  - 7. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
  - 8. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.

- 9. Steps: Individual FRP steps wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals.
- 10. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
- 11. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.
- B. Manhole Frames and Covers:
  - 1. Description: Ferrous; per City of Farmington Hills. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

# 2.5 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R, and the following:
  - 1. Cement: ASTM C 150, Type II.
  - 2. Fine Aggregate: ASTM C 33, sand.
  - 3. Coarse Aggregate: ASTM C 33, crushed gravel.
  - 4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
  - 1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
  - 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.
- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
  - 1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
  - 2. Benches: Concrete, sloped to drain into channel.
- D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.
  - 1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
  - 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

## 2.6 CATCH BASINS

A. Standard Precast Concrete Catch Basins:

- 1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
- 2. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
- 3. Riser Sections: 4-inch minimum thickness, 48-inch diameter, and lengths to provide depth indicated.
- 4. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
- 5. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
- 6. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
- 7. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch total thickness, that match 24-inch- diameter frame and grate.
- 8. Steps: Individual FRP steps wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals.
- 9. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.
- B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading.
  - 1. Size: 24 by 24 inches minimum unless otherwise indicated.
  - 2. Grate Free Area: Approximately 50 percent unless otherwise indicated.

## PART 3 - EXECUTION

## 3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

## 3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

- F. Install gravity-flow, nonpressure drainage piping according to the following:
  - 1. Install piping pitched down in direction of flow.

# 3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure drainage piping according to the following:
  - 1. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
  - 2. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasketed joints.
  - 3. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
  - 4. Join dissimilar pipe materials with nonpressure-type flexible couplings.

# 3.4 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
- B. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

## 3.5 MANHOLE INSTALLATION

- A. General: Install manholes, complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

# 3.6 CATCH BASIN INSTALLATION

- A. Construct catch basins to sizes and shapes indicated.
- B. Set frames and grates to elevations indicated.

## 3.7 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318.

## 3.8 IDENTIFICATION

- A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
  - 1. Use detectable warning tape over ferrous piping.
  - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

## 3.9 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
  - 1. Submit separate reports for each system inspection.
  - 2. Defects requiring correction include the following:
    - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    - d. Infiltration: Water leakage into piping.
    - e. Exfiltration: Water leakage from or around piping.
  - 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
  - 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
  - 1. Do not enclose, cover, or put into service before inspection and approval.
  - 2. Test completed piping systems according to requirements of authorities having jurisdiction.
  - 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
  - 4. Submit separate report for each test.
  - 5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
    - a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
    - b. Option: Test plastic piping according to ASTM F 1417.
    - c. Option: Test concrete piping according to ASTM C 924.
- C. Leaks and loss in test pressure constitute defects that must be repaired.
- D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

## 3.10 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

# END OF SECTION 33 4100