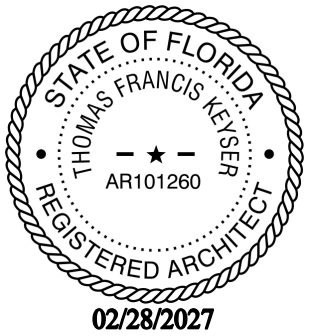
**PROJECT MANUAL**
**BID PACKAGE TWO**

**VOLUME TWO**

**FOR**




# ESCAMBIA COUNTY
# AREA TRANSIT FACILITY
# 100 CLARINDA LANE
# PENSACOLA, FLORIDA 32505

**BY**

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**DATE: OCTOBER 22, 2026**
**PROJECT NO. 2613**

VOLUME TWO: Fire Suppression, Plumbing, Heating, Ventilating, and Air Conditioning (HVAC), Electrical, Communications, Electronic Safety and Security, Earthwork, and Exterior Improvements

Issue Date: October 22, 2026

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**END OF SECTION**

# SECTION 210500

# FIRE PROTECTION COMMON WORK RESULTS

## PART 1 - GENERAL

### 1.1 SCOPE

A. Perform all Work required to provide and install the equipment and systems indicated by the Contract Documents with supplementary items necessary for proper installation.

### 1.2 REFERENCES

A. Fire protection work shall comply with specification section 230500.

B. In addition to Division 21, Fire Protection work shall comply with the following sections:
   1. Section 230500 HVAC Common Work Results
   2. Section 230529 Pipe Hangers and Supports
   3. Section 230553 Mechanical Identification
   4. Section 230593 Cleaning and Testing

### 1.3 SUBMITTALS

A. Submittals must be reviewed and approved by the Contractor before submitting to the Engineer.

### 1.4 REGULATORY AND UTILITY REQUIREMENTS

A. Contractor is responsible for coordinating all required site inspections by authorities having jurisdiction. Contractor shall notify General Contractor of all scheduled inspections seven (7) working days prior to site visit.

B. Contractor is responsible for paying for all fees, permits, and inspections required to complete their work.

C. Contractor shall include all work required to install new and relocate utilities and meters as shown on drawings.

D. Utility work 5’-0” from outside of building is by others, unless shown otherwise.

E. Contractor shall notify Owner of any utility service shutdown 48 hours in advance.

1.5 COORDINATION DRAWINGS

A. The mechanical contractor shall be responsible for producing coordination drawings. The drawings will need to incorporate piping, ductwork, equipment, lighting, conduits, building structure and all other building and system components that will need to be coordinated for proper systems installation and operation.

B. The fire protection contractor shall provide all necessary information to the mechanical contractor to produce coordination drawings. The contractor shall also attend and participate in all coordination meetings.

C. The drawings will be 1/4" scale.

D. Coordination meetings will be conducted on site with all concerned contractors present. Representatives from the Owner, Architect and Engineer will also be present to review conflicts and approve contractor variations to the contract documents.

PART 2 - PRODUCTS

2.1 PAINT

A. For indoor applications, use paints and primers that have a VOC content of 250 g/L or less when calculated according to the adopted version of the Green Seal Standard GC-03, Anti-Corrosive Paints.

PART 3 - EXECUTION

3.1 CONCRETE BASES

A. Refer to specification section 230500 and individual equipment specifications for additional requirements.

3.2 PAINTING

A. Exposed piping in occupied areas to be painted by others. Refer to specification section 099100. Coordinate color with architect.
   1. Contractor to prep piping as needed to accept paint.

B. Contractor shall paint the following items with two (2) coats of exterior enamel over one (1) coat primer. Select paint to be compliant with material being used, i.e. metal, plastic, etc:
   1. All exposed fire protection piping. Color to be coordinated with the Architect.
   2. Sprinkler heads and sprinkler head cover plates shall not be painted.

**END OF SECTION**

# SECTION 211300

# SPRINKLER SYSTEMS

## PART 1 - GENERAL

### 1.1 SCOPE

A. Perform all Work required to provide and install the equipment and systems indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
   1. Pipes, fittings, and specialties
   2. Fire-protection valves
   3. Fire-department connections
   4. Sprinklers
   5. Alarm devices
   6. Control panels
   7. Pressure gauges

C. System Pressure
   1. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.
   2. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig, but not higher than 250 psig.

D. System Descriptions
   1. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water that is connected to a water supply through an alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts a fusible link.

### 1.2 REFERENCES

A. All materials, installation and Workmanship shall comply with the applicable requirements and standards addressed within the following references:
   1. Factory Mutual System (FM) - Approval Guide and Loss Prevention Data Sheets
   2. UL – Underwriters Laboratory
   3. NFPA 13 – Standard for the Installation of Sprinkler Systems
   4. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems
   5. NFPA 25 – Standard for the Inspection, Testing and Maintenance of Water – Based Fire Protection Systems
   6. NFPA 13R – Standard for the Installation of Sprinkler Systems in Low Rise Residential Occupancies

1.3 SUBMITTALS

A. Review Procedure
   1. Contractor shall submit the shop drawings, working plans including product data and hydraulic calculations where applicable, to the Owner's Insurance Agency and Engineer for review. Review shall be based on applicable NFPA Standards, current version or as specified in the construction document.
   2. Owner's Insurance Agency shall provide review comments back to the Engineer.
   3. Engineer shall consult with the Owner prior to applying comments from the Owner's Insurance Agency and return the shop drawings with review comments back to the Contractor. Repeat the process until the Engineer approves the submittals.
   4. Contractor shall submit the Engineer/Owner approved shop drawings to the State Fire Marshal for final approval prior to installation.

B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings: For all sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.

D. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

E. Fire-hydrant flow test report.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

G. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing design services needed to assume responsibility. Base calculations on results of fire-hydrant flow test.

B. Sprinkler drawings shall be designed and stamped by a NICET III or NICET IV certified designer.

C. Design sprinkler system(s) per NFPA 13, using performance requirements and design criteria indicated.

D. Sprinkler system shall be hydraulically designed and have a density of at least that required by the hazard rating of the area protected.

E. Pipe sizes shall be no less than 1". The velocity of water in pipe shall not exceed 20 ft/sec

F. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

G. Center sprinkler heads in ceiling tiles in both directions.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 1.5 EXTRA MATERIALS

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

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six (6) spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

# PART 2 - PRODUCTS

## 2.1 BACKFLOW PREVENTER

A. Acceptable Manufacturers
1. Apollo / Conbraco
2. Watts / Febco / Ames Fire & Waterworks
3. Zurn / Wilkins
4. Viking

## 2.2 FIRE DEPARTMENT CONNECTIONS/FIRE PUMP TEST CONNECTIONS

A. Acceptable Manufacturers
1. Croker
2. FPPI
3. Potter Roemer

## 2.3 GAUGES

A. Acceptable Manufacturers
1. AMETEK
2. Ashcroft

## 2.4 SPRINKLERS

A. Acceptable Manufacturers
   1. Reliable
   2. Tyco
   3. Victaulic
   4. Viking

## 2.5 VALVES – ANGLE/BALL/BUTTERFLY/CHECK/GATE

A. Acceptable Manufacturers
   1. Anvil
   2. FPPI
   3. Kennedy Valve
   4. Milwaukee Valve
   5. Nibco
   6. Tyco Fire
   7. Victaulic

## 2.6 WATER MOTOR OPERATED GONG

A. Acceptable Manufacturers
   1. Tyco Fire
   2. Victaulic
   3. Viking

## 2.7 ELECTRICALLY OPERATED ALARM BELL

A. Acceptable Manufacturers
   1. Notifier
   2. Potter

## 2.8 WATER FLOW INDICATORS

A. Acceptable Manufacturers
   1. McDonnell & Miller (ITT Industries)
   2. Potter Roemer
   3. System Sensor (Honeywell)
   4. Viking

## 2.9 PRESSURE SWITCHES

A. Acceptable Manufacturers
   1. Potter Roemer
   2. System Sensor (Honeywell)
   3. Tyco

4. Viking

## 2.10 VALVE SUPERVISORY SWITCHES

A. Acceptable Manufacturers
   1. Kennedy
   2. Potter Roemer
   3. System Sensor (Honeywell)

B. Post Indicator Supervisory Switches
   1. Potter Roemer
   2. System Sensor (Honeywell)

## 2.11 PIPING USAGE SCHEDULE

A. Refer to piping usage schedule on drawings for specific system requirements.

## 2.12 STEEL PIPE AND FITTINGS (GENERAL REQUIREMENTS)

A. Standard Weight, Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Hot dipped galvanized where indicated. Pipe ends may be factory or field formed to match joining method.

B. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends, hot dipped galvanized where indicated.

C. Steel Couplings: ASTM A 865, threaded, hot dipped galvanized where indicated.

D. Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern, hot dipped galvanized where indicated.

E. Malleable- or Ductile-Iron Unions: UL 860.

F. Cast-Iron Flanges: ASME 16.1, Class 125.

G. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

H. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

I. Grooved-Joint, Steel-Pipe Appurtenances
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Shurjoint Piping Products
      b. Tyco Fire & Building Products LP
      c. Victaulic Company.
   2. Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe, hot dipped galvanized where indicated.

3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

## 2.13 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.
   1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
   2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

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

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

## 2.14 LISTED FIRE-PROTECTION VALVES

A. General Requirements
   1. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.
   2. Minimum Pressure Rating for High-Pressure Piping: 250 psig.
   3. Body Material: Cast or ductile iron.
   4. Size: Same as connected piping.
   5. End Connections: Flanged, threaded or grooved.

## 2.15 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings
   1. Standard: UL 213.
   2. Pressure Rating: 175 psig minimum.
   3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
   4. Type: Mechanical-T and -cross fittings.
   5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
   6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
   7. Branch Outlets: Grooved, plain-end pipe, or threaded.

## 2.16 SPRINKLERS

A. General Requirements
   1. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
   2. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig minimum.

3. Temperature Rating: 165° F minimum. Contractor to verify required sprinkler temperatures based on space usage and location.

B. Open Sprinklers with Heat-Responsive Element Removed: UL 199.
   1. Characteristics
      a. Nominal 1/2" Orifice: With Discharge Coefficient K between 5.3 and 5.8.
      b. Nominal 17/32” Orifice: With Discharge Coefficient K between 7.4 and 8.2.

C. Automatic Sprinklers with Heat-Responsive Element
   1. Early-Suppression, Fast-Response Applications: UL 1767.
   2. Nonresidential Applications: UL 199.
   3. Characteristics: Nominal 1/2" orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
   4. Element Type: Glass bulb.

D. Flexible Head Sprinklers
   1. 300 series stainless steel braided hose between sprinkler system branch piping and sprinkler. Connection to branch piping can be grooved or threaded.
   2. Provide with carbon steel, zinc - plated brackets to secure the sprinkler to the ceiling or ceiling grid.
   3. Rated for a minimum of 150 deg F for UL projects and 225 deg F for FM projects.
   4. Minimum working pressure of 300 psi
   5. Minimum bend radius of 3” for UL projects and 8” for FM projects.
   6. Flexible hoses available in ranges from 30” – 72” and 1” in diameter with ½” and ¾” sprinkler head connection adaptors.

E. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

F. Sprinkler Guards
   1. Type: Welded steel guard with baseplate mounted directly to sprinkler piping.
   2. Standard: UL 199.

## 2.17 PRESSURE GAUGES

A. Standard: UL 393.

B. Dial Size: 3-1/2” to 4-1/2” diameter.

C. Pressure Gauge Range: 0 to 250 psig minimum.

D. Water System Piping Gauge: Include "WATER" or "AIR/WATER" label on dial face.

E. Air System Piping Gauge: Include "AIR" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing to Owner and Engineer.

3.2 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.

C. Fire service piping shall be installed to meet the cover requirements as noted in NFPA 13. Coordinate exact requirements for the project location with NFPA 13. For central Iowa a minimum requirement of 66” of cover (12” below frost depth) shall be met.

3.3 PIPING INSTALLATION

A. 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.

B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

D. Install unions adjacent to each valve in pipes 2” and smaller.

E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having 2-1/2” and larger end connections.

F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13. Unless indicated otherwise, inspector's test connections shall be located at the end of the most remote branch line in the upper story. Test valve shall be located not over 7' above the floor and in lockable rooms. Discharge shall be to floor drain equipped with a funnel.

G. Install sprinkler piping with drains for complete system drainage. Terminate drain lines to the nearest floor drain with funnel or to a service sink.

H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

I. For combined sprinkler / standpipe systems, install 2-1/2" hose valve and sprinkler control assembly including OS&Y valves with tamper, flow switch, and inspector's test and drain valves in each floor. Connect drain lines to drain risers.

J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

K. Install alarm devices in piping systems. A flow alarm switch shall be provided in the sprinkler riser and shall be wired into the fire alarm system. Where a main line branches out, a separate alarm shall be installed on each branch to a different building or section of building. A separate flow alarm switch for the standpipe risers is not required for the combined system.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than 1/4" and with soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they will not be subject to freezing.

N. Fill sprinkler system piping with water.

O. Underground pipe and fittings for fire protection shall be installed in accordance with AWWA specification. Refer to Water Distribution Section in Division 2 for details.

## 3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

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 pipes, tubes, and fittings before assembly.

D. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

E. 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.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

G. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

H. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

I. Solvent Joints: Follow manufacturer's instructions for set and cure times for solvent cement joints. Avoid significant stresses during set and cure times. Do not apply any stress that will disturb an un-dried joint. Sprinkler fittings shall be allowed to cure in accordance with the manufacturer's guidelines and the contractor shall assure the outlets are clear of any excess cement prior to installing sprinklers.

## 3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 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. System water supply valves, isolation control valves, and other valves in feed mains shall be supervised by locking valves open. Provide owner approved padlocks.

D. Install backflow preventers in potable-water-supply sources.

E. Specialty Valves:
1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.

F. Deluge Valves: Install in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

## 3.6 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels. Center sprinkler in tile in both directions.

B. Install sprinklers in a reasonably symmetrical pattern in areas with finished drywall ceilings.

C. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

## 3.7 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire-department connections as indicated in the construction documents.

B. Install yard-type, fire-department connections in concrete slab support. Comply with requirements for concrete in Division 03 Section "Cast-in-Place Concrete."

C. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

## 3.8 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. All exposed sprinkler piping in unfinished areas shall be painted red. All exposed piping in finished areas shall be painted to match the adjoining walls and ceilings or a color selected by the Architect.

A. At intervals not to exceed 50 feet, provide printed identification and flow direction labels entitled "SPRINKLER FIRE." Refer to Specification Section 230553 – Mechanical Identification for required pipe label requirements. Labels shall be snap on or adhesive style equal to Seton "Setmark."

## 3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections
   1. Leak Test: After installation, charge systems 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. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
   4. Energize circuits to electrical equipment and devices.

5. Coordinate with fire-alarm tests. Operate as required.
6. Verify that equipment hose threads are same as local fire-department equipment.

C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.11 DEMONSTRATION

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

**END OF SECTION**

**SECTION 220500**

**PLUMBING COMMON WORK RESULTS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the equipment and systems indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Plumbing work shall comply with specification section 230500.

B. In addition to Division 22, Plumbing work shall comply with the following sections:
   1. Section 230500 HVAC Common Work Results
   2. Section 230529 Pipe Hangers and Supports
   3. Section 230553 Mechanical Identification
   4. Section 230593 Cleaning and Testing
   5. Section 230594 Testing Adjusting and Balancing
   6. Section 230719 Piping Insulation

1.3 SUBMITTALS

A. Submittals must be reviewed and approved by the Contractor before submitting them to the Engineer.

1.4 REGULATORY AND UTILITY REQUIREMENTS

A. Contractor is responsible for coordinating all required site inspections by authorities having jurisdiction. Contractor shall notify General Contractor of all scheduled inspections seven (7) working days prior to site visit.

B. Contractor is responsible for paying for all fees, permits, and inspections required to complete their work.

C. Contractor shall include all work required to install new and relocate utilities and meters as shown on drawings.

D. Utility work 5’-0” from outside of building is by others, unless shown otherwise.

E. Contractor shall notify Owner of any utility service shutdown 48 hours in advance. This includes water, sanitary, and storm systems.

## 1.5 SUBSTITUTIONS

A. All manufacturers listed as Acceptable Manufacturers in each specification section are considered equal to the basis of design. The basis of design is preferred and will take precedence. Any products from an alternate approved manufacturer need to meet the requirements and performance specified and shall be equal to the basis of design.

B. The Contractor may request permission for a substitution of any item (equipment or material), subject to the following conditions:
   1. Submit substitution requests in writing to the Engineer, on a form supplied by the Engineer. A sample copy of this form is included at the end of this section. An electronic copy can also be provided to the Contractor by the Engineer.
   2. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contractor documents, the Contractor is responsible for all costs involved in integrating the equipment or accessories into the system and the assigned space and for obtaining the performance from the system into which these items are placed as well as any re-design costs incurred by the Architect or Engineer. The Contractor is also responsible for coordinating changes required by other trades.
   3. Any requests for alternate manufacturers must be submitted to the Architect/Engineer at least ten (10) days prior to bid day. Incomplete substitution requests will not be considered.

C. Approval
   1. No work involving requests for substitution shall commence without written approval on the provided form by the Engineer.
   2. Any work started or material ordered/installed by the Contractor without written approval shall be removed/repaired at the sole expense of the Contractor. The Contractor will also be responsible for any costs incurred by the Owner for such rework.

## 1.6 COORDINATION DRAWINGS

A. The mechanical contractor shall be responsible for producing coordination drawings. The drawings will need to incorporate piping, ductwork, equipment, lighting, conduits, building structure and all other building and system components that will need to be coordinated for proper systems installation and operation.

B. The plumbing contractor shall provide all necessary information to the mechanical contractor to produce coordination drawings. The contractor shall also attend and participate in all coordination meetings.

C. The drawings will be 1/4" scale.

D. Coordination meetings will be conducted on site with all concerned contractors present. Representatives from the Owner, Architect and Engineer will also be present to review conflicts and approve contractor variations to the contract documents.

PART 2 - PRODUCTS

2.1 PAINT

A. For indoor applications, use paints and primers that have a VOC content of 250 g/L or less when calculated according to the adopted version of the Green Seal Standard GC-03, Anti-Corrosive Paints.

PART 3 - EXECUTION

3.1 PAINTING

A. Exposed piping in occupied areas to be painted by others. Coordinate color with architect.
   1. Contractor to prep piping as needed to accept paint.

B. Contractor shall paint the following items with two (2) coats of exterior enamel over one (1) coat primer. Select paint to be compliant with material being used, i.e. metal, plastic, etc:
   1. All exposed plumbing piping. Color to be coordinated with the Architect.

**END OF SECTION**

**SECTION 220523**

**PLUMBING VALVES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Plumbing Valves indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
1. All valves shown on the plumbing drawings.
2. Valves to isolate all plumbing fixture groups.
3. Valves to isolate water heaters and other plumbing equipment.
4. Valves to isolate owner provided equipment.
5. Valves for makeup water connections serving hydronic systems.

1.2 REFERENCES

A. Abbreviations
1. IBBM: Iron body, bronze mounted.
2. OS&Y: Outside screw and yoke.
3. WOG: Water, oil, gas.
4. WSP: Working steam pressure.

1.3 SUBMITTALS

A. Product Data: Catalog sheets, specifications and installation instructions for each valve type.

B. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements
1. Comply with the most recent version following standards:
a. Safe Drinking Water Act (SDWA) and the associated lead content requirements.

PART 2 - PRODUCTS

2.1 VALVES - GENERAL

A. Acceptable Manufacturers (unless specified otherwise)
   1. Apollo/Conbraco
   2. Crane
   3. Hammond
   4. HCI
   5. Milwaukee
   6. Nibco
   7. Stockham
   8. Victaulic
   9. Viega
   10. Watts

B. Valve Standardization: Valves from one or more manufacturers may be used, however valves supplied for each specific valve type shall be the product of one manufacturer.

C. Valves shall be first quality, free from all imperfections and defects, with body markings indicating manufacturer and rating.

D. Valve parts of same manufacturer, size and type shall be interchangeable.

E. Valves which use packing shall be capable of being packed when wide open and under full working pressure.

F. Size valves the same size as the piping in which they are installed, unless specified otherwise.

G. Provide extended shafts for all valves installed on insulated piping.

H. Coordinate the end connection type with the piping and other specialties in the systems. Refer to the piping usage schedule for additional requirement. The following are acceptable styles:
   1. Solder
   2. Mechanical press
   3. Threaded
   4. Flanged
   5. Grooved

I. Provide unions in the system as needed for installation or removal of valves and specialties.

J. Manually operated gate, globe and angle valves shall be of rising stem type, unless otherwise specified.

## 2.2 GATE VALVES

A. GT-1: 200 psig WSP, IBBM with non-toxic, corrosion resistant coating inside and out, FDA-approved, OS&Y, non-rising stem. Valve rated for 175 psi and designed to connect to the indicator post. Bolted bonnet, resilient solid wedge disc, completely and permanently encapsulated in rubber. Delrin Anti-friction thrust bearing. UL listed. AWWA C509 Acceptable Valve.

B. Indicator post provided by Fire Protection Contractor. Coordinate requirements and installation with Fire Protection Contractor.

C. Coordinate end connection type with site utility contractor.

## 2.3 CHECK VALVES

A. CK-1: 125 psig WSP; 200 psig WOG; bronze body; brass, bronze, or 304 stainless steel trim; Y-pattern; horizontal swing; renewable/regrindable bronze seat disc.

B. CK-2: 125 psig WSP; 200 psig WOG; bronze body; brass, bronze, or 304 stainless steel trim; Y-pattern; horizontal swing; renewable/regrindable PTFE seat disc.

C. CK-3: 125 psig WSP; 200 psig WOG; IBBM;; bolted bonnet; full port; horizontal swing regrindable/renewable cast bronze seat ring and disc. Discs on valves 4 inch size and larger may be cast iron with bronze face.

## 2.4 BALL VALVES

A. BV-1: 150 psig WSP, 600 psig WOG, two (2) piece bronze body, full-port, solid blow-out proof 316 stainless steel stem, PTFE seats, 316 stainless steel ball, PTFE seals, corrosion resistant steel lever handles with vinyl grips, and balancing stop.

## 2.5 BUTTERFLY VALVES

A. BF-1: Ductile iron body, flangeless wafer, grooved, or lugged type, (lug for each bolt hole, drilled and tapped for cap screws), with resilient PTFE or EPDM seats, ductile iron discs, stainless steel stems, and raised necks able to accommodate 2 inches of insulation.
   1. Pressure Ratings:
      a. 12 inch size and Less: 200 psig WOG at 275° F.
      b. 14 inch size and Up: 150 psig WOG at 275° F.

B. Operators
   1. 6 inch size and Less: Manual actuator handles with external indication of disc position, memory stop, and suitable means of locking actuator in any fixed position.
   2. 8 inch size and Up: Worm gear operator.

## 2.6 WATER PRESSURE REDUCING VALVES

A. Main Water Service
   1. Acceptable Manufacturers:
      a. Fisher
      b. Kieley
      c. Mueller

2. Valve shall be an adjustable, direct acting, spring loaded, diaphragm operated, single seat, bottom guided type suitable for dead end service; guaranteed not to stick and shall maintain a constant discharge pressure which will not vary more than 1 psig for each 10 psig decrease in inlet pressure. Valves shall have cast iron, mild steel or bronze bodies. Valve trim shall be of stainless steel with renewable composition disc. Parts subject to wear shall be renewable.

3. Material of diaphragm and disc shall be suitable for an operating temperature to 150° F. The control line, from diaphragm casing, shall be connected to the discharge piping at least ten (10) feet downstream from pressure reducing valve. Control line shall be of same material as adjoining piping. Valves shall be standard weight for inlet pressures up to 125 psig, and extra heavy weight for inlet pressures in excess of 125 psig.

## 2.7 BALANCING VALVES

A. Automatic Type
   1. Acceptable Manufacturers:
      a. Circuit Solver
      b. Or approved equal that shall meet performance characteristics
   2. Valve shall regulate the flow of recirculated domestic hot water based on water temperature entering the valve regardless of system operating pressure. As the water temperature increases the valve proportionally closes dynamically adjusting flow to meet the specified temperature. The valve shall never fully close, even at the desired set point. There is always sufficient bypass flow back to the recirculating pump to prevent overheating or "dead heading" of the pump.
   3. The valve shall be set at the factory for the desired return temperature. No field adjustments are required. The following factory temperature set points are available.
      a. 100°F / 105°F / 110 °F / 115°F / 120°F / 125°F / 130°F / 140°F
   4. The hot water system temperatures shall have the corresponding hot water recirculation temperatures:
      a. 140°F hot water temp / 125°F hot water circ temp
   5. The valve shall stay fully open at approximately 10°F below closing temperature.
   6. The assembly shall be available in ½", ¾" and 1"
   7. Valve body and all internal components are made with lead free materials with major components constructed of type 303 stainless steel.
      a. Valve rated to 200 PSIG maximum working pressure and 250°F maximum working temperature.
   8. Thermal actuator shall be spring loaded and self cleaning, delivering closing thrust sufficient to keep orifice opening free of scale deposits.
   9. Install valve in each domestic hot water return piping branch beyond last hot water device in that branch.
   10. Balancing valves to be provided with the following accessories as indicated on the drawings:
      a. Check valve
      b. Strainer (20 mesh)
      c. Thermometer
      d. Ball valve (assembly inlet and outlet)

11. Coordinate flow arrow, especially with valves that have an integrated check valve

## 2.8 SAFETY AND RELIEF VALVES

A. General Requirements: Valves shall be as specified by ASME Code governing manufacture of such valves within scope of their particular usage, i.e., Heating Boilers, Unfired Pressure Valves, etc., shall be tested, rated and listed, unless otherwise specified. Valves for applications specified shall conform to the ASME Code, Section IV, Heating Boilers and the following:
   1. Valves for combination domestic hot water heater and storage tanks shall conform to the requirements of ASME Code, Section IV and USA Standard Z21.22 and shall be NBB listed. Valves shall be of the temperature - pressure type. Thermostatic element shall, on rising temperature, cause the valve to open at 200° F and valve shall deliver its rated capacity at 210° F and close drip tight at 195° F. Valves shall be sized in accordance with Unfired Vessel Code.
   2. End Connections: Unless otherwise specified, safety valves, relief valves and safety relief valves, in sizes 3/4 inch to 3 inches IPS inclusive, may be furnished with male or female pipe thread inlet and female pipe thread outlet; valves over 3 inches IPS must be furnished with 125 lb. or 250 lb. inlet and may be equipped with 125 lb. outlet.

## 2.9 GAUGE COCKS

A. Acceptable Manufacturers:
   1. Marsh Instrument Company
   2. Mueller Instruments Co.
   3. H.O. Trerice Co.
   4. Weksler Instruments Corp.

B. Gauge Cocks: All brass construction, “T” or lever handles, built for 300 psig hydraulic pressure.

## 2.10 STRAINERS

A. Acceptable Manufacturers:
   1. Zurn
   2. Watts
   3. Or approved equal that shall meet performance requirements

B. All strainers to be of constructed of lead free brass, bronze, or copper and shall be rated for use in potable water systems and shall meet the requirements of NSF/ANSI 372. Strainers shall include 20 mesh stainless steel strainer screen and tapped access cover and pipe plug.

## 2.11 HEAT TRAP FITTING

A. Acceptable Manufacturers
   1. Rheem/Ruud

2. Prior approved equal
3. Or approved equal that shall meet performance requirements

B. Dielectric nipple-style heat trap to prevent heat loss through top water heater storage tank connections. Plastic ball flow control with inert thermoplastic lining for anti-corrosion. Heat trap fitting shall be factory-marked (color coded or flow direction stamped) for hot and cold installations. Ball seat to allow for thermal expansion bypass.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. General: Install valves at locations noted on the drawings and as specified below:.
1. Install isolation valves at branch takeoffs from mains.
2. Install a common isolation valves for branch lines to each group of fixtures.
3. Install isolation valves above ceiling (in an accessible location) for each fixture if fixture is not provided with integral stops.

### 3.2 VALVE APPLICATION SCHEDULE

A. Schedule of valve applications for the different services is as follows:
1. Cold Water, Domestic Hot Water and Circulating (CW, HW, HWC) located inside building, 125 psig and Less:
   a. 3 inch and Less: BV-1, CK-1, CK-2.
   b. 4 inch and Up: BF-1, CK-3.
2. Building Water Service
   a. GT-1

**END OF SECTION**

**SECTION 221100**

**PLUMBING PIPING**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Plumbing Piping Systems indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in this section:
   1. Cold Water
   2. Hot Water
   3. Hot Water Recirculation
   4. Sanitary
   5. Vent
   6. Storm
   7. Water Service

1.2 REFERENCES

A. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
   1. The adopted version of the Florida Plumbing Code shall be applicable to this Project unless identified by a specific edition date.

1.3 SUBMITTALS

A. Product Data
   1. Catalog sheets and specifications indicating manufacturer name, pipe/fitting type, applicable reference standard, schedule, or class for specified pipe and fittings.
   2. Material Schedule: Itemized pipe and fitting material list for each specified piping application in Pipe and Fittings Schedule as defined in Part 3 of this specification section. Where optional materials are specified indicate option selected.

B. Submit piping layout drawings as per specification section 230500 HVAC Common Work Results.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements
   1. Comply with the most recent version following standards:

a. Safe Drinking Water Act (SDWA) and the associated lead content requirements.

2. Use only materials and methods allowed by applicable codes and authority having jurisdiction (AHJ). It is the contractor's responsibility to confirm if plastic piping is acceptable with the AHJ prior to installation.

B. Qualification of Brazers

1. Comply with the following: The persons performing the brazing and their supervisors shall be personally experienced in brazing procedures.

## 1.5 EXTRA MATERIALS

A. Provide new manual pipe cutting and crimp ring tools for PEX piping. Crimping tool shall be capable of crimping joints for all sizes of piping installed on job. Tools shall be same as pipe manufacturer. Tools shall include instructions.

# PART 2 - PRODUCTS

## 2.1 STEEL PIPE AND FITTINGS

A. Steel Pipe for Threading: Standard weight, Schedule 40, black; ASTM A 53 or ASTM A 135.

B. Steel Pipe for Roll Grooving: Standard weight, Schedule 40, black; ASTM A 53, Grade B, Type F for sizes 3/4" to 1-1/2", and Type E or S for sizes 2" to 24", or ASTM A 135.

C. Malleable Iron, Steam Pattern Threaded Fittings

1. 150 lb Class: ASME B16.3.
2. 300 lb Class: ASME B16.3.

D. Cast Iron Fittings

1. Drainage Pattern, Threaded: ASME B16.12.
2. Steam Pattern, Threaded: ASME B16.4.
   a. Standard Weight: Class 125.
   b. Extra Heavy Weight: Class 250.
3. Flanged Fittings and Threaded Flanges: ASME B16.1.
   a. Standard Weight: Class 125.
   b. Extra Heavy: Class 250.

E. Unions: Malleable iron, 250 lb class, brass to iron or brass to brass seats.

F. Couplings: Same material and pressure rating as adjoining pipe, conforming to standards for fittings in such pipe. Use taper tapped threaded type in screwed pipe systems operating in excess of 15 psig.

G. Nipples: Same material and strength as adjoining pipe, except nipples having a length of less than one inch between threads shall be extra heavy.

2.2 COPPER AND BRASS PIPE, TUBING AND FITTINGS

A. Copper Tube, Types K and L: ASTM B 88.

B. Wrought Copper Tube Fittings, Solder Joint: ASME B16.22.

C. Cast Copper Alloy Tube Fittings, Solder Joint: ASME B16.18.

D. Drainage Tube, Type DWV: ASTM B 306.

E. Wrought Copper Drainage Tube Fittings, Solder Joint: ASME B16.29.

F. Cast Copper Alloy Drainage Fittings, Solder Joint: ASME B16.23.

G. Chrome Plated Grade A Red Brass Threaded Pipe, Standard Weight: ASTM B 43.
   1. Plating: 0.02 mil chromium over 0.2 mil nickel plating, high polish finish.Unions: Cast bronze, 150 lb Class, bronze to bronze seats, threaded or solder joint.

H. Flared Tube Fittings
   1. Water Tube Type: ASME B16.26.

I. Flanges: Conform to the Standards for fittings used in systems.
   1. Brazing Flanges: ASME B16.24, hubs modified for brazing ends.

J. Mechanical Press Fittings
   1. Copper with EPDM seals; ASME B16.51, NSF-61.

2.3 CAST IRON PIPE AND FITTINGS

A. Bell and Spigot Soil Pipe: Service Weight, Bitumin coated; ASTM A 74, CISPI/NSF. All pipes shall be marked with CISPI and NSF listing.

B. Bell and Spigot Soil Pipe Fittings: Service Weight, Bitumin coated; ASTM A 74, CISPI/NSF.

C. Bell and Spigot Soil Pipe Gaskets: ASTM C564

D. Hubless Pipe: Bitumin coated; CISPI Standard No. 301. All pipes shall be marked with CISPI and NSF listing.

E. Hubless Pipe Fittings: Drainage Pattern, Bitumin coated; CISPI No. 301.

F. Hubless Joint Couplings: Stainless steel shield and clamp assembly, and elastomer sealing sleeve; CISPI-310.

2.4 DUCTILE IRON PIPE AND FITTINGS

A. Water Pipe: Bitumin coated and cement-mortar lined; AWWA C151.
   1. 3”- 4”: Class 51.

2. 6” and Over: Class 50.

B. Fittings: Bitumin coated and cement-mortar lined; AWWA C110.

## 2.5 COUPLINGS AND FITTINGS FOR GROOVED END PIPE

A. Couplings: Gruvlok Fig. 7401 or 74, or Victaulic Co.’s Style 07 or 107, having minimum pressure rating of:
1. 750 psi from 1-1/2” to 4”
2. 700 psi for 6”
3. 600 psi for 8”

B. Couplings: Gruvlok Fig. 7001, or Victaulic Co.’s Style 77, having pressure rating of:
1. 1000 psi for 3/4" to 6”
2. 800 psi for 8” to 12”
3. 300 psi for 14” to 24”

C. Fittings: By same manufacturer as couplings, having pressure ratings equal to or greater than couplings. Comply with the following standards:
1. Steel: ASTM A 53 or A 106, Grade B.
2. Malleable Iron: ASTM A 47.
3. Ductile Iron: ASTM A 536.

## 2.6 PEX PIPING AND FITTINGS

A. Acceptable Manufacturers:
1. Uponor
2. Rehau
3. Or approved equal that shall meet performance requirements

B. Pipe: Pex-a (Engel Method Crosslinked Polyethylene Piping) for potable water use. Meets ASTM Standards F-876, F-877 and E84, NSF Standards 14, 61 & 372, PEX 5306.
1. Color: Piping may be white, red, or blue in color. If red/blue colored piping is used, red must be used for all hot water pipe and blue for cold water. Maintain color scheme throughout building.
2. Note: If using color coded tubing as described above, then labeling of these pipes may be omitted.

C. Fittings: All fittings used with crosslinked polyethylene (PEXa) water distribution pipe shall be cold-expansion fittings with PEXa reinforcing ring. Meets ASTM Standard F1960. Fittings same as pipe manufacturer. All fittings shall be completely brass or polymer. Use copper stub-outs for fixture rough-ins, PEX shall not be exposed out of the wall at fixture rough-ins.
1. Brass fittings to be lead-free ECO Brass UNS C69300
2. Polymer fittings in accordance to ASTM D 6394

D. Valves: Lead-free brass ball valve.
1. Manufacturer: valve from same manufacturer as piping system.

2. Ball valve: full-port, two-piece, positive stop shoulder, ASTM F1960 cold-expansion ends with PEXa reinforcing ring.

E. Accessories: Stub-out plates shall be used to support rough-in piping for fixture connections.

## 2.7 PVC PIPING AND FITTINGS

A. Pipe: Schedule 40 PVC , Type I, rated for 140° F, ASTM D2665

B. Fittings: Same as pipe manufacturer; ASTM D2466. Solvent welded using solvent approved by manufacturer.

## 2.8 CPVC VENT PIPE AND FITTINGS

A. Pipe: Schedule 40 CPVC, Type IV Grade I rated for 220° F at no pressure, ASTM D 2618, NSF. Minimum cell classification of 23447. All pipe, fittings and cement shall be supplied as a system by a single manufacturer and shall be certified by NSF International for use in corrosive waste drainage systems and shall bear the mark “NSF-cw”.

B. Fittings: Same as pipe manufacturer, complying with ASTM F438 socket types. Solvent welded using manufacturer provided solvent rated for laboratory chemical use, ASTM F493. Includes all piping starting at the fixture served until the piping leaves the building or discharges to an acid neutralization tank.

C. Fire Spread/Smoke Developed Rating of 25/50 or less based on ASTM E 84.

D. Buried pipe shall be installed in accordance with ASTM D 2321 and ASTM F 1668.

## 2.9 JOINING AND SEALANT MATERIALS

A. Thread Sealant
1. LA-CO Industries’, Slic-Tite Paste with Teflon.
2. Loctite Corp.’s No. 565 Thread Sealant.
3. Thread sealants for potable water shall be NSF approved.

B. Solder: Solid wire type conforming to the following:
1. Lead-free tin-silver solder (ASTM B 32 Alloy Grade E, AC, or HB)

C. Brazing Alloys
1. Type 1: AWS A5.8, Class BCuP-5, for brazing copper to brass, bronze, or copper.
2. Type 2: AWS A5.8, Class BAg-7, for brazing copper to steel or stainless steel.

D. Brazing Flux: FS O-F-499, Type B.

E. Gaskets For Use With Ductile Iron Water Pipe and Cast Iron Drainage Pipe: Synthetic rubber rings (molded or tubular): Clow Corp.'s Belltite, Tyler Pipe Industries Inc.'s Ty-Seal, or U.S. Pipe and Foundry Co.'s Tyton.

F. Flange Gasket Material
   1. For Use With Cold Water: 1/16" thick rubber.
   2. For Use With Hot Water, Air or Steam: Waterproofed non-asbestos ceramic or mineral fiber, or a combination of metal and water-proofed non-asbestos ceramic or mineral fiber, designed for the temperatures and pressures of the piping systems in which installed.

G. Gaskets For Use With Grooved End Pipe and Fittings: Type and materials as recommended and furnished by the fitting manufacturer, for the service of piping system in which installed.

H. Anti-Seize Lubricant: Bostik Inc.'s Never Seez or Dow Corning Corp.'s Molykote 1000.

## 2.10 PACKING MATERIALS FOR BUILDING CONSTRUCTION PENETRATIONS

A. Oiled Oakum: Manufactured by Nupak of New Orleans, Inc. or approved equal that shall meet performance requirements.

B. Mechanical Modular Seals: Thunderline Corp.'s Link Seal wall and floor seals or approved equal that shall meet performance requirements designed for the service of piping system in which installed.

## 2.11 DIELECTRIC CONNECTORS

A. Use for all connections between piping connections of dissimilar materials.

B. Unions
   1. Rated 250 psig at 180° F; ASME B16.39; Wilkins Model DU.
   2. Rated 100 psig at 210° F; ASME B16.39; Wilkins Model DU with high temperature gasket.
   3. Rated Above 100 psig and 210° F: Use Flange Electrical Insulation Kit specified below.

C. Flange Electrical Insulation Kit: Consisting of dielectric sleeves and washers, and dielectric gasket.
   1. Rated 150 psi at 250° F: ANSI Class 150, full faced neoprene gasket with bolt holes, double phenolic washers, and Mylar sleeves; Model 150 by APS, Lafayette, LA.

## 2.12 PIPE SLEEVES

A. Install pipe sleeves as noted on the drawings or indicated in this specification section. The following piping material shall be used as noted in the installation section in this specification:
   1. Type A: Schedule 40 steel pipe.
   2. Type B: No. 16 gauge galvanized sheet steel.

3. Type C: Schedule 40 steel pipe with 1/4" steel collar continuously welded to pipe sleeve. Size steel collars as required to span a minimum of one (1) cell or corrugation, on all sides of the rough opening thru the metal deck.
4. Type D: No. 16 gauge galvanized sheet steel with 16 gauge sheet steel metal collar rigidly secured to sleeve. Size metal collars as required to span a minimum of one (1) cell or corrugation, on all sides of the rough opening thru the metal deck.

## 2.13 PIPING ESCUTCHEONS

A. Cast Brass: Polished chrome plated finish, with set screw.

B. Cast Iron: Solid type, unplated, with set screw; Model 395 by Grinnell Corp.

## 2.14 THERMOMETERS

A. Acceptable Manufacturers
1. Weiss Instruments
2. Or approved equal that shall meet performance requirements

B. Bi-Metal Thermometers
1. Body: Type 304 Stainless Steel, heavy glass face, and hermetically sealed.
2. Bimetallic Element: Bimetallic element calibrated to meet temperature standards of manufacturer and helix assembly with silicon dampening.
3. Stem: Stainless steel to match body and of a length to suit installation. Bare stem shall be used for hydronic systems in non-corrosive applications.
4. Connector: ¾ inch, with ASME B1.1 screw threads.
5. Accuracy: Plus or minus 1 percent of scale range or one scale division, to maximum of 1.5 percent of scale range.
6. See piping application schedule for thermometer range requirements based on system type.

C. Liquid in Glass Thermometers
1. Body: Molded plastic with variable angle mounting compliant with ASME B40.200.
2. Tube: Glass with magnifying lens, blue organic liquid, nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
3. Stem: Aluminum or brass and of a length to suit installation. Bare stem shall be used for hydronic systems in non-corrosive applications.
4. Connector: ¾ inch, with ASME B1.1 screw threads.
5. Accuracy: Plus or minus 1 percent of scale range or one scale division, to maximum of 1.5 percent of scale range.
6. See piping application schedule for thermometer range requirements based on system type.

D. Digital Thermometer
1. Body: Molded plastic with variable angle mounting.
2. Stem: Aluminum or brass and of a length to suit installation. Bare stem shall be used for hydronic systems in non-corrosive applications.

3. Connector: ¾ inch, with ASME B1.1 screw threads.
4. Display: Digital
5. Accuracy: Plus or minus 2 deg F.
6. Provide thermowell compatible with thermometer based on pipe diameter and system of installation.
7. See piping application schedule for thermometer range requirements based on system type.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Piping shall be stored to prevent debris from entering the piping. This shall consist of piping caps or temporary covers.

B. Above or below grade piping that is roughed in shall have a temporary cap installed to prevent debris from entering the piping system. The cap shall be removed to allow for the final connection or continuation of piping to be installed.

C. Install piping at approximate locations indicated, and at maximum height.

D. Install piping clear of door swings, and above sash heads.

E. Make allowances for expansion and contraction.

F. Install expansion loops in PEX piping as recommended by manufacturer.

G. Allow for a minimum of 1” free air space around pipe or pipe covering, unless otherwise specified.

H. Install all underground piping outside the footprint of the building to meet the minimum cover and distance below the frost depth requirements listed below:
   1. Sanitary and Storm – 48” minimum cover (below frost depth)
   2. Domestic water service – 12” below frost depth of the local jurisdiction or 60” deep, whichever is greater.
   3. Fire service - 12” below frost depth of the local jurisdiction or 72” deep, whichever is greater.

I. Fire service piping shall be installed to meet the cover requirements as noted in NFPA 13. Coordinate exact requirements for the project location with NFPA 13.

J. Install horizontal piping with a constant pitch, and without sags or humps.
   1. Water Piping: Pitch 1/4" per 10 feet upward in direction of flow, unless otherwise noted. If it is not possible to maintain constant pitch, establish a new low point and continue. At the low point, provide a 1/2" drip leg and gate valve with a hose bibb end. Provide an air vent at the high point.

2. Sanitary Piping: Pitch piping 3” and Under 1/4" per foot downward, in direction of flow, unless otherwise noted. Pitch piping 4” and Over 1/8” per foot downward, in direction of flow, unless otherwise noted.
3. Grease Sanitary Piping: Pitch piping 1/4" per foot downward, in direction of flow, unless otherwise noted.
4. Vent Piping: Pitch 1/8" per foot upward, unless otherwise noted.

K. Install vertical piping plumb.

L. Use fittings for offsets and direction changes, except for Type K soft annealed copper temper water tube, and mechanically extracted joints in Type L copper tubing.

M. Cut pipe and tubing ends square; ream before joining.

N. Threading: Use American Standard Taper Pipe Thread Dies.
1. Thread brass pipe with special brass threading dies.

O. PEX shall only be allowed individual branch or fixture piping, not mains connecting more than one (1) room.
1. PEX piping shall not be installed in rated walls or ceiling spaces being used as a return air plenum.
2. PEX piping shall not be installed where exposed, this includes mechanical rooms.

## 3.2 DRAINAGE SYSTEMS

A. Fittings
1. Long Sweep Fittings
   a. Long sweep fittings shall be those in the category where 4” diameter piping has a minimum R/D = 10.5”/4”.
   b. Use long sweep drainage pattern fittings for all fittings unless noted otherwise.
   c. Use of other fittings must be approved by Engineer in writing prior to use.
2. Short Sweep Fittings
   a. Short sweep fittings shall be those in the category where 4” diameter piping has a minimum R/D = 7.5”/4”.
   b. Short sweep drainage pattern fittings may be used for the following.
      1) Vent piping.
      2) Fixture connections.
      3) Other locations as approved by the Engineer in writing.
3. Vertical Offsets: Make vertical offsets with 45° elbows, or 1/8 bends.

B. Cleanouts
1. Install cleanouts with sufficient side and end clearance to allow for the removal of the cleanout plug, and the use of cleaning tools.
2. Lubricate cleanout plugs with anti-seize lubricant.

## 3.3 DOMESTIC WATER PIPING SYSTEM

A. Connect branch lines to the upper quadrant of the main, and run upward at not less than 45° before extending laterally.

B. Make final connections to plumbing fixtures and equipment with unions, or flanges.
   1. Do not use unions in ferrous piping larger than 3".
   2. Do not use unions in brass or copper piping larger than 2-1/2".

3.4 PIPE JOINT MAKE-UP

A. Threaded Joint: Make up joint with a pipe thread compound applied in accordance with manufacturer's printed application instructions for the intended service.
   1. Chrome Plated Brass Pipe: Tighten joint with a strap or Parmalee wrench; do not mar pipe finish. Install piping so that no threads are visible.

B. Soldered Joint: Thoroughly clean tube end and inside of fitting with emery cloth, sand cloth, or wire brush. Apply flux to the pre-cleaned surfaces. Install fitting, heat to soldering temperature, and join the metals with type of solder specified. Remove residue.

C. Flanged Pipe Joint
   1. Install threaded companion flanges on steel pipe; flanges on galvanized pipe are not required to be galvanized.
   2. Provide a gasket for each joint.
      a. Hot Water Pipe Gasket: Coat with a thin film of oil before making up joint.
   3. Coat bolt threads and nuts with anti-seize lubricant before making up joint.

D. Caulked Joint: Pack hub with joint packing specified, and caulk. Run 12 ounces molten lead for each inch of pipe diameter. Caulk cooled lead ring and face off smoothly.

E. Rubber Ring Push-on Joint: Clean hub, bevel spigot, and make up joint with lubricated gasket in conformance with the manufacturer's printed installation instructions.

F. Grooved Pipe Joint: Roll groove pipe ends, make up joint with grooved end fittings and couplings, in conformance with the manufacturer's printed installation instructions.
   1. Cut grooved end piping is not acceptable.

G. Hubless CI Pipe Joint: Make up joint with hubless fitting and couplings, in conformance with the manufacturer's printed installation instructions.

I. Mechanical Joint: Make up joint in conformance with the manufacturer's printed installation instructions, with particular reference to tightening of bolts.

J. Mechanical Press Joint: Install joint with tool approved by joint manufacturer. Installer shall be fully trained and have experience in installing this type of joint.

K. PEX Joint: Cut pipe and install joints with tool approved by joint manufacturer. Installer shall be fully trained and have experience in installing this type of joint.

M. Dissimilar Pipe Joint

1. Joining Bell and Spigot and Threaded Pipe: Install a half coupling on the pipe or tube end to form a spigot, and caulk into the cast iron bell.
2. Joining Dissimilar Threaded Piping: Make up connection with a threaded coupling or with companion flanges.
3. Joining Dissimilar Non-Threaded Piping: Make up connection with adapters recommended by the manufacturers of the piping to be joined.

## 3.5 PIPING PENETRATIONS

A. Install pre-manufactured flexible boots for vent terminations through roof. Use materials compatible with roof system.

B. Sleeve Schedule: Unless otherwise shown, comply with the following schedule for the type of sleeve to be used where piping penetrates wall or floor construction:

| | CONSTRUCTION | SLEEVE TYPE |
|---|---|---|
| 1. | Frame construction. | None Required |
| 2. | Foundation walls. | A* |
| 3. | Non-waterproof interior walls. | B* |
| 4. | Non-waterproof interior floors on metal decks. | D* |
| 5. | Non-waterproof interior floors not on metal decks. | B* |
| 6. | Floors not on grade having a floor drain. | A |
| 7. | Floors over mechanical equipment, steam service, machine, and boiler rooms. | A |
| 8. | Floors finished or to be finished with latex composition or terrazzo, and on metal decks. | D* |
| 9. | Floors finished or to be finished with latex composition or terrazzo, and not on metal decks. | A |
| 10. | Earth supported concrete floors. | None Required |
| 11. | Exterior concrete slabs on grade. | A |
| 12. | Fixtures with floor outlet waste piping. | None Required |
| 13. | Metal roof decks. | C |
| 14. | Non-metal roof decks. | A |
| 15. | Waterproof floors on metal decks. | D |
| 16. | Waterproof floors not on metal decks. | A |
| 17. | Waterproof walls. | A |

*Core drilling is permissible in lieu of sleeves where marked with asterisks.

C. Diameter of Sleeves and Core Drilled Holes
1. Unless otherwise specified, size holes thru floors and walls in accordance with the through penetration fire stopping system being used.
2. Size holes thru exterior walls or waterproofed walls above inside earth or finished floors, and exterior concrete slabs in accordance with the following:
   a. Uninsulated (Bare) Pipe: Inside diameter of sleeve or core drilled hole 1/2" greater than outside diameter of pipe, unless otherwise specified.

b. Insulated Pipe: Inside diameter of sleeve or core drilled hole 1/2" greater than outside diameter of insulation, unless otherwise specified.
c. Mechanical Modular Seals: Size holes in accordance with the manufacturer's recommendations.

D. Length of Sleeves (except as shown otherwise on Drawings)
1. Walls and Partitions: Equal in length to total finished thickness of wall or partition.
2. Floors, Finished: Equal in length to total finished thickness of floor and extending 1/2" above the finished floor level, except as follows:
a. In furred spaces at exterior walls, extend sleeve 1" above the finished floor level.
3. Exterior Concrete Slabs: Equal in length to total thickness of slab and extending 1/2" above the concrete slab.
4. Roofs: Equal in length to the total thickness of roof construction, including insulation and roofing materials, and extending one inch above the finished roof level.

E. Packing of Sleeves and Core Drilled Holes
1. Unless otherwise specified, pack sleeves or cored drilled holes in accordance with Section 07 84 00 - FIRESTOPPING.
2. Pack sleeves in exterior walls below grade and concrete floor slabs at or below with mechanical modular seals.

## 3.6 ESCUTCHEONS

A. Install plates for exposed uninsulated piping passing thru floors, walls, ceilings, and exterior concrete slabs as follows:
1. In Finished Spaces: chrome plated cast brass.
2. Unfinished Spaces (Including Exterior Concrete Slabs): unplated cast iron.
3. Fasten plates with set screws.
4. Plates are not required in pipe shafts or furred spaces.

## 3.7 PIPE AND FITTING SCHEDULE

A. Refer to Drawings for Piping Application Schedule.

B. Where options are given, choose only one (1) option for each piping service. No deviations from the selected option will be allowed.

**END OF SECTION**

**SECTION 221429**

**SUMP AND SEWAGE EJECTOR PUMPS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Pump Systems indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
   1. Pumps
   2. Basins
   3. Controls
   4. Accessories

1.2 REFERENCES

A. All equipment to be UL listed and labeled.

1.3 SUBMITTALS

A. Product Data
   1. Catalog sheets, specifications, installation instructions, including pump capacity curve (capacity vs. head) and electrical schematics.
   2. Catalog sheets, specifications, and installation instructions for the sump basin and cover.

1.4 QUALITY ASSURANCE

A. Each pump shall be operated in liquid at the factory prior to being shipped. The unit will be checked at the maximum operating point for performance, amps, grounding, winding insulation and watertightness.

PART 2 - PRODUCTS

2.1 ELEVATOR SUMP PUMPS WITH OIL DETECTION

A. Acceptable Manufacturers
   1. Goulds
   2. F.E. Myers
   3. Zoeller

B. Pump Construction
   1. Type: Completely submersible, automatic operation, with a screenless suction, non-clog impeller, and lifting bail.
   2. Approved by UL 778 Standards.
   3. Motor Requirements
      a. Equip submersible motor with built-in thermal overload protection.
      b. Rated for continuous or intermittent operation.
   4. Materials
      a. Casing, exterior covers and caps: Painted cast iron.
      b. Impeller: Thermoplastic.
      c. Shaft: Stainless steel, sealed against contact with moisture.
      d. Exterior fasteners: Stainless steel.
   5. Liquid Temperature: Design to handle liquids up to 140° F maximum.

C. Oil Detection System
   1. Provide pump and control systems capable of pumping water while containing oil. The system shall function automatically and shall provide for an alarm and separate LED lights in the event of any of the following:
      a. The presence of oil in the sump
      b. High liquid in the sump
      c. High amps or a locked rotor condition
   2. LED lights shall be provided for the following:
      a. Power
      b. Pump run function
   3. An alarm that sounds only in the event of a high liquid condition or does not separately identify the above five functions shall not be acceptable.

D. Control Panel
   1. The main control shall be approved to UL 508 standards and housed in a gasketed Nema 4X enclosure with a see-through window for observation of operating functions.
   2. The control panel shall be equipped with the following:
      a. Eight (8)-pin twist lock receptacle
      b. Dual solid state relays with variable sensitivity settings
      c. Over current relay
      d. Self-cleaning stainless steel sensor probe
      e. High decibel warning horn with alarm silencing switch
      f. Dual floats
      g. Clearly marked terminal board and remote monitoring contact.
   3. A Nema 4X junction box with 8-pin twist-lock electrical receptacle and 25' minimum of mating eight (8) conductor cable shall be provided. Provide additional cable as site specific requirements dictate.
   4. All cables between the pump and junction box shall be 16' long and the cable and plug from the control unit shall be 8' long. The control unit, junction box, pump, floats and sensor shall be factory assembled as a complete, ready-to-use system and shall be tested and approved as a complete system by a nationally recognized testing laboratory.
   5. The system shall allow for the main control to be located outside of the elevator hoistway to be monitored for all functions without having to enter the elevator shaft.
   6. An auxiliary set of contacts shall be provided to allow for interface with the building automation system to send a general alarm.

E. Sump
   1. Sump Basin: Fiberglass with hubbed inlets, and flanged top drilled and tapped for bolted cover.
   2. Accessories: Provide with pump removal guide rails and stainless steel removal cables as supplied by pump manufacturer.
   3. Basin Cover: Perforated cast iron, drilled for bolting to sump basin. Fabricate openings in cover for pump access, power cord and discharge pipe. Provide rubber grommet in cover to protect power cord.
   4. Liquid Temperature: Design to handle liquids up to 140° F maximum.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install the Work of this Section in accordance with the manufacturer's printed installation instructions unless otherwise specified.

B. High Water Alarm: Install high water alarm and make electrical connections. Install liquid level control device at proper elevation to activate alarm at specified liquid depth. Secure control device to pump discharge pipe with clamps or to side of sump basin with corrosion resistant brackets and fasteners.

C. Floor Stand: Secure to floor with lag bolts and expansion shields.

D. Control Panel: Install and make electrical connections. Install liquid level control devices at elevation required to produce specified sump drawdown. Secure control devices to pump discharge pipe with clamps, or to side of sump basin with corrosion resistant brackets and fasteners.

E. Control Panel: Mount wall panel where directed and secure with suitable fasteners.

F. Sump: Install sump basin on a level firm base, make piping connections.

G. Install sump cover.

### 3.2 PUMP OPERATION

A. Single Pump System: Set level controls to start pump when liquid depth in sump reaches field adjustable setpoint and stop pump when liquid depth reaches field adjustable setpoint.

B. High Water Alarm Setting: Set control device to sound alarm when liquid depth in the sump reaches field adjustable setpoint.

3.3 FIELD QUALITY CONTROL

A. Test sump pump system for proper operation at specified liquid depths.

B. Test high water alarm for proper operation at specified liquid depth.

C. Test oil detection system for proper operation.

**END OF SECTION**

**SECTION 221500**

**COMPRESSED AIR SYSTEMS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Compressed Air Systems indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
1. Compressed air piping
2. Air compressor
3. After cooler
4. Receiver tank
5. Air dryer
6. Air filters
7. Air outlets

1.2 REFERENCES

A. Refer to the compressed air flow diagram and plan drawings on the documents for additional system and performance requirements.

1.3 SUBMITTALS

A. Product Data: Catalog sheets, specifications, rough-in dimensions, electrical requirements, and installation instructions for each item specified except fasteners.

1.4 QUALITY ASSURANCE

A. Comply with the following standards:
1. ASME Standards pertaining to Receiver Tanks, Pressure Vessels, Safety Valves, and Low-Pressure Compressed Air System Piping.

PART 2 - PRODUCTS

2.1 COMPRESSED AIR PIPING

A. Steel Pipe System (Rated for 150 psig):

1. Pipe: ASTM A53, Schedule hot-dip zinc coated with threaded ends.
2. Fittings: ASME B16.3, galvanized, malleable iron.
3. Joints: Threaded

B. Copper Pipe System (Rated for 150 psig)
1. Pipe: ASTM B88, Type L drawn copper
2. Fittings: ASME B16.18 cast copper alloy or ASME B16.22, wrought copper and bronze.
3. Joints: ASTM B32, solder, Grade 95TA.

C. Aluminum Quick Connect System (Rated for 150 psig)
1. Pipe: Extruded aluminum 6060 T5 and powder coated in RAL5012 blue. Available in 1/2" – 4" sizes.
2. Fittings and Joints: Push to fit system
3. Acceptable Manufacturer: Transair or prior approved equal

D. Steel Pipe System (Rated for 150 psig)
1. Pipe: ASTM A 135, Schedule 5, carbon steel with plain ends and zinc-plated finish.
2. Pressure-Seal Fittings: Listed and labeled by a qualified testing agency and FMG-approved, carbon-steel, pressure-seal housing with O-ring end seals suitable for compressed-air piping and rated for 300-psig (2070-kPa) minimum working pressure. Provide EDPM seals for oil-free compressed air. Provide NBR seals if compressed air contains oil or oil vapor.

## 2.2 AIR COMPRESSORS

A. Acceptable Manufacturers
1. Atlas Copco
2. Campbell Hausfeld
3. Ingersol Rand
4. Quincy

B. Rotary Screw Compressors
1. General: Shall be capable of operating against pressure of 125 psig V-belt connected, electric motor drive, with provision for belt adjustment. Provide air compressor, air receiver, after-cooler, filter muffler and inline filter.
2. Compressor: Reciprocating or rotary, receiver mounted. Maximum speed 1400 RPM. Lubrication system may be automatic flood system or forced feed.
3. Air Receiver: Galvanized steel, built in accordance with applicable requirements of ASME Code for Unfired Pressure Vessels for a working pressure of 150 psig and shall be stamped and certified. Equipment receiver with pressure gage, lever-type safety valve and drain cock. Support receiver on saddles having bearing area extending one third shell circumference or with leg supports having equivalent bearing area.
4. Motor and Starter: 105° F ambient temperature rise type motor, ball bearing, voltage and phase as indicated in schedule on drawings, conforming to NEMA standards, maximum speed 1800 RPM. Motor shall be of sufficient size to operate compressor without overloading. Provide each motor with automatic, fully enclosed, magnetic starter, controlled by a hand-off-auto switch.

## 2.3 AFTER COOLERS

A. Construction: Removable tube nests of non-ferrous metal tubes and corrosion resistant tube plates, safety valves, pressure gauge, moisture separator, moisture drain valve, water inlet piping with automatic water valve, automatic condensate trap and overflow piping with open funnel.

B. Working pressure: 150 psi.

C. Discharge: Cool air to within 12˚ F of ambient air temperature specified with flow capacity.

## 2.4 RECEIVER TANKS

A. Receiver tank shall be vertical or horizontal as indicated on the Contract Drawings. The receiver shall be an ASME stamped pressure vessel.

B. Accessories
1. ASME certified pressure relief valve.
2. Gate valve for air discharge.
3. Pressure gauge.
4. Manual drain valve.
5. Automatic tank drain valve

## 2.5 AIR DRYERS

A. Refrigerant type air dryer matching the rated capacity and max pressure of the compressed air system as noted on the drawings.

B. Unit shall have a built in oil and dirt removal filter and a pre-cooler section to improve energy efficiency. A separator with moisture accumulator and timer solenoid valve for moisture removal shall be provided to maintain high efficiency separation and prevent moisture carry over. No outside cooling water supply or external cooling packages are allowed.

C. Air Connection: Inlet and outlet connection at same level, factory insulated.

D. Heat Exchanger: Air to air and refrigerant to air coils. Furnish heat exchangers with automatic control system to bypass refrigeration system on low or no load conditions.

E. Moisture Separator: Centrifugal type located at discharge of heat exchanger.

F. Refrigeration Unit: Hermetically sealed type ot operate continuously to maintain specified 21˚ F dew point. Enclose unit in a steel cabinet with access door and panel for maintenance and inspection. Unit shall use R-134a, R-407c or R-410a.

G. Accessories: Air inlet temperature gage, air inlet pressure gauge, on / off switch, high temperature light, power on light, refrigerant gauge, air outlet temperature gauge, air outlet pressure gauge.

2.6 COALESCING AIR FILTERS

A. Filters to be provided as indicated on the drawings. Filters shall be rated to trap all 0.3 micron sized particles and above. Filter shall be rated at a minimum of 200 psig. A pressure drop indicator shall be provided to show when filter element should be replaced. An automatic moisture drain shall be provided.

2.7 PIPING ACCESSORIES

A. Condensate trap drains: Trap drains shall consist of brass, bronze or 304 stainless steel bowl and internal components. Internal components shall consist of float, outlet valve and piston that automatically open to eject moisture that has collected in the system. Unit shall be rated for 150 psig inlet pressure. Materials shall be compatible with synthetic compressor oils.

PART 3 - EXECUTION

3.1 INSTALLATION (PIPING)

A. Install piping true to line and grade, supported and guided to ensure alignment under all conditions. Installed piping shall clear obstruction, preserve headroom and keep openings and passageways clear.

B. All air line branch connections shall be made off the top of the header. All condensate drains connections shall be made off the bottom of the piping. Lines shall be pitched toward drip legs and receivers.

C. Install drip legs and automatic drain traps at all low points in the system. Pipe condensate drains to floor drains or other acceptable locations.

D. Valves shall be accessible for operation and servicing. Valves located in furred spaces shall be accessible through access panels or access doors. Valves shall be installed as required and shall not be installed having stems located below the horizontal position.

E. Pipe joints on copper piping shall be made with soldered connections unless otherwise noted or required.

F. Threaded joints shall only be made with PTFE sealing tape. Thread sealing compounds shall not be used.

G. Install unions at each connection to valves, equipment, and tanks. Soldered-to-threaded connections shall be made-up with male thread-to-soldered adaptors.

H. After installation of pipes, end of pipes shall be either capped or plugged. No piping shall be buried, furred in, or concealed before being inspected and tested.

I. Provide access panels in accordance with the architectural specifications.

3.2 INSTALLATION (AIR COMPRESSOR)

A. Install, align, connect, and test the equipment in accordance with the manufacturer's installation instructions and recommendations.

B. Pipe drains to nearest floor drain or acceptable location.

C. Make adjustments required to place system in proper operating condition in accordance with the manufacturer's instructions and recommendations.

D. Set pressure switches as required.

E. Install compressor on a neoprene pad. All piping and conduit connections to the compressor shall be made using a flexible connector. Refer to section 230548 for vibration isolation requirements.

3.3 FIELD TESTS (PIPING)

A. Test compressed air piping system, pneumatically in sections, to a pressure of at least 175 psi for not less than 15 minutes witnessed by the engineer. Repair leaks and retest the system until the system is leak free. Test sequence shall be as follows:
   1. Lines shall be blown out.
   2. Lines shall be pneumatically tested.

3.4 FIELD TESTS (AIR COMPRESSOR)

A. Perform field tests for each installation in the presence of the Engineer. The contractor shall give 48 hours notice to the Engineer prior to the test. Provide all necessary instruments, test setup, connections, labor and tools for testing. Defective workmanship, materials and equipment shall be corrected or replaced in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer at no additional cost to the Owner. All corrected work shall be retested to ensure compliance with these specifications.

B. Field tests shall demonstrate workmanship, operation, and performance. Each test attribute shall be completed to the satisfaction of the Engineer. Submit a written record indicating that the following items have been completed:
   1. Compressor starts below the switch set point.
   2. Compressor stops at switch set point.
   3. Automatic drain valve discharges.
   4. Operation of pressure relief valves.

**END OF SECTION**

**SECTION 223300**

**DOMESTIC WATER HEATERS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Domestic Water Heaters indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Water heater shall be UL listed and labeled.

B. Water heater shall bear the seal of the American Gas Association.

C. Comply with the Iowa State Energy Code.

D. Water heater performance shall meet the adopted version of ASHRAE 90.1.

E. Water heaters serving emergency fixtures shall meet all requirements of ANSI Z358.1 for tepid water.

1.3 SUBMITTALS

A. Product Data: Catalog sheets, specifications and installation instructions for each water heater, gas vent pipe, fittings, and accessories required for the vent system.

1.4 WARRANTY

A. Manufacturer's Warranty: Three (3) year warranty for the glass lined water heater tank. Provide a copy of the warranty as part of the closeout documents.

PART 2 - PRODUCTS

2.1 INSTANTANEOUS WATER HEATER

A. Acceptable Manufacturers
   1. Rheem
   2. A.O. Smith
   3. Rinnai

4. Lochinvar

B. Unit to be used to serve building as indicated on the drawings.

C. Microprocessor controls with temperature setpoint display and adjustment knob located on the front of the cabinet for unit located in secure area. A vandal resistant option shall be available for units located in public areas.

D. Water heater is capable of adjusting the water temperature between 100˚ F and 140˚ F based on an entering water temperature of 60˚ F.

E. Heating Elements: Stainless steel electric heating coil (electric), immersion type, replaceable; 75 watts per square inch maximum watt density (natural gas).

F. Wiring: Factory interwired, requiring only a single field electric connection to put the heater into service.

G. Outer Casing: Steel with baked enamel or acrylic finish. Access door for servicing thermostats, heating elements, and controls. Approved for 0" clearance to combustibles.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install the Work of this section in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

B. Install the water heater on a level, firm base.

C. Install the pressure-temperature relief valve in the dedicated tank tapping. Pipe the relief valve blow-off to a point 6 inches above the floor, or as shown on drawings.

D. Install unions and shut-off valves on hot and cold water connections. Install dielectric unions if required.

E. Flush and fill tank. Do not switch on heating elements until tank is full and entrapped air is eliminated. Install the Work of this section in accordance with NFPA 54, NFPA 211, and the manufacturer's printed installation instructions, unless otherwise specified.

F. Install an AGA lubricated plug valve on the gas connection. Gas supply branch shall have a 6" dirt leg with a threaded cap.

G. Vent Piping
1. Support horizontal piping on five (5) foot centers, maximum spacing, support vertical piping at every floor or ten (10) foot intervals maximum.
2. Install manufacturer provided concentric vent kit.

**END OF SECTION**

**SECTION 224000**

**PLUMBING FIXTURES AND EQUIPMENT INSTALLATION**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Plumbing Fixtures and Equipment indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Refer to the Plumbing Material Lists and Equipment Schedules for additional capacity and equipment requirements.

1.3 SUBMITTALS

A. Fixture and Equipment Data: Catalog sheets, specifications, rough-in dimensions, and installation instructions for each item specified except fasteners.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements
   1. Comply with the most recent version following standards:
      a. Safe Drinking Water Act (SDWA) and the associated lead content requirements.
      b. Applicable sections of ANSI/ASME A112 – Standards for Plumbing Equipment
   2. Materials and installations designated as handicapped accessible shall conform with the following:
      a. ANSI A117.1 - Buildings and Facilities - Providing Accessibility and Usability for Physically Handicapped People.
      b. The Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG), (Appendix A to 28 CFR Part 36).
   3. Each fixture carrier support shall be listed by model number in the fixture support manufacturer's Fixture Support Selection Guide as being recommended for support of the appropriate fixture.

B. Plainly and permanently mark each fixture and fitting with the manufacturer's name or trade mark.

C. Acid resistant surfaces shall be plainly and permanently marked with the manufacturer's label or symbol indicating acid resistance.

1.5 MAINTENANCE

A. Special Tools: Deliver to the Owner.
   1. Furnish the following tools labeled with names and locations where used.
      a. Keys for stops (furnished with stops).
      b. Tools for Vandal Resistant Fasteners: Two (2) for each type and size.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The following manufacturers are considered equal to the basis of design listed in the material list and schedules. The basis of design is preferred and will take precedence. Any products from an alternate approved manufacturer need to meet the requirements and performance specified and shall be equal to the basis of design.

| Equipment | Acceptable Manufacturers |
|---|---|
| Backflow | Apollo/Conbraco, Watts/Febco/Ames, Zurn/Wilkins |
| Domestic Water Circulation Pumps | Armstrong, Bell & Gossett, Grundfos, Taco |
| Drainage Fixtures | Josam, Mifab, Smith, Sun, Wade, Watts, Zurn |
| Electric Water Coolers | Elkay or approved equal that shall meet performance characteristics |
| Emergency Fixtures | Acorn, Bradley, Encon, Guardian, Haws, Speakman |
| Expansion Tanks | Amtrol, Armstrong, Bell & Gossett, Elbi, Taco, Watts |
| Fixture Carriers | Jay R. Smith, Josam, Zurn |
| Flush Valves | Sloan, Zurn, or approved equal that shall meet performance characteristics |
| Garbage Disposal | InSinkErator, Waste King |
| Hose Bibbs & Misc. Valves | Acorn, Zurn, or approved equal that shall meet performance characteristics |
| Lavatories, Urinals, Water Closets (Fixtures) | Acorn, American Standard, Eljer, Kohler, Sloan, Toto, Zurn |
| Lavatory & Sink Trim | American Standard, Chicago Faucet, Delta Commercial, Kohler, Moen Commercial, T&S Brass, Sloan, Zurn |
| Mixing Valves | Armstrong, Bradley, Lawler, Leonard, Powers |
| Mop And Service Sinks | Fiat, Stern-Williams, Zurn |
| Sand / Oil Interceptor | Striem, Mifab, Rockford, Zurn |
| Shower Fixtures | American Standard, Aqua Bath, Aquatic |
| Shower Trim | Bradley, Chicago Faucet, Lawler, Leonard, Moen Commercial, Powers, Symmons, Toto, Zurn |
| Stainless Steel Sinks | Elkay, Just, Kohler |
| Wall Boxes | Guy Gray, LSP, Oatey, Sioux Chief |
| Water Hammer Arrestors | Sioux Chief, Watts, Jay R. Smith, Zurn |

B. All items shall be commercial grade unless specified otherwise.

C. All items shall be supplied by the same manufacturer.

## 2.2 FIXTURE MATERIALS

A. Vitreous China: First quality, smooth, uniform color and texture, with fused on glaze covering surfaces exposed to view.
   1. Surfaces shall be free of chips, craze, warpage, cracks and discolorations. Surfaces in contact with walls or floors shall be flat, with warpage not to exceed 1/16 inch per foot.
   2. Color: White.

B. Porcelain Enameled Cast Iron: Smooth, uniform color and texture, having fused on glaze covering surfaces exposed to view.
   1. Material shall show no cracks, chips, craze or discolorations.
   2. Enameled surfaces shall be acid resistant unless otherwise specified.
   3. Color: White.

C. Fixture Trim: Brass, bronze, or stainless steel construction; consisting of supply and waste fittings, faucets, traps, stop valves, escutcheons, sink strainers, nipples, supplies, and metal trim.
   1. Brass piping: IPS standard weight, with standard weight, 125 lb cast brass fittings.
   2. Brass tubing: 18 B & S gauge.
   3. Stainless steel: 18-8 Type 302 or 304 unless otherwise specified.

D. Fixture Trim: Acid Waste Systems
   1. Tail pieces and p-traps for fixtures connected to acid waste systems shall be constructed of similar material to the acid waste piping.

E. Fixture Trim Finishes:
   1. Brass or Bronze: Polished or satin finished chrome plating, 0.02 mil chromium over 0.2 mil nickel plating.
   2. Stainless Steel: Invisible welds and seams, and unless otherwise specified, polished to No. 4 commercial finish.

F. Fixture Hold-down Bolts: Steel, plated for corrosion resistance.
   1. Cap nuts: Metal, polished and chrome plated.
   2. Vandal Resistant Fasteners: Torx head with center pin.

## 2.3 FIXTURE SUPPORTS AND SUPPORTING DEVICES FOR LAVATORIES, SINKS, AND EQUIPMENT

A. General: Ferrous metal members of carriers and supporting devices, with the exception of chrome plated or porcelain enameled cast iron, shall be factory painted for corrosion resistance.

B. Floor Mounted Carrier Supports: Steel pipe uprights, 1-1/4 inch IPS minimum diameter, or 1 inch x 2 inch steel tubing uprights, with cast iron or welded steel feet, drilled for bolting to the floor construction. Each carrier shall be provided with the appropriate fixture supporting devices specified, or recommended by the carrier manufacturer's Fixture Support Selection Guide.Floor mounted carrier supports for banks of multiple adjacent fixtures shall have provisions in the support uprights to allow for waste piping to be concealed in the associated wall.

2. Concealed Arms: Steel, with fixture locking lugs, leveling screws and a means of attaching, positioning and securing the fixture to the carrier.
   a. Trim: Polished, chrome plated metal escutcheon to space fixture two inches from the wall.
3. Exposed Arms: Cast iron or steel, porcelain enamel finished, with locking lugs, and leveling screws. Include studs, nuts and washers for fixture to be supported.
   a. Trim: Polished and chrome plated metal cap nuts and washers.
   b. Vandal Resistant Trim: Polished, chrome plated metal cap nuts and washers retained with vandal resistant set screws or other approved means of securing trim.

C. Wall Mounted Carrier Supports: Plate type system, with steel plates on both sides of the wall and through-bolted. On walls having an integral finish, a single plate wall carrier designed for such installations may be used. Each carrier shall be provided with the appropriate fixture supporting devices specified, or recommended by the Carrier manufacturer's Fixture Support Selection Guide.
   1. Concealed Arms: Steel, with fixture locking lugs, leveling screws and a means of attaching, positioning and securing the fixture to the carrier.
      a. Trim: Polished, Chrome plated metal escutcheon to space fixture two inches from the wall.
   2. Exposed Arms: Cast iron or steel, porcelain enamel finished, with locking lugs, and leveling screws. Include studs, nuts, and washers for fixture to be supported.
      a. Trim: Polished and chrome plated metal cap nuts and washers.
      b. Vandal Resistant Trim: Polished, chrome plated metal cap nuts and washers retained with vandal resistant set screws.

D. Bearing Plate: Steel, minimum 1/8 inch thick, and provided with bearing studs, nuts and appurtenances required by the fixture to be supported.
   1. Fixture Hanger: Furnished by the fixture manufacturer.

E. Wood Stud Filler Piece: 2 inch x 8 inch wood planking cut to fit between wood studding. Fasten with four 3/8 inch x 2-1/2 inch lag bolts with washers.

F. Water Closet Carriers
   1. Closet Carrier (For Wall Hung Water Closets): Commercial type cast iron combination chair carrier and drainage fitting with the following:
      a. Capacity: 1,000 pounds.
      b. Face Plate: Cast iron; height adjustable.
      c. Feet: Cast iron, adjustable, with provisions for bolting to the floor slab.
      d. Studs, Nuts and Washers: Steel, treated for corrosion resistance.
      e. Fixture Washers: Plastic.
      f. Adjustable Closet Connection: Cast iron, steel, or ABS plastic.
      g. Fitting Ends: Compatible with the drainage piping system.
      h. Gasket: Impregnated felt or neoprene closet gasket; lead or neoprene face plate gasket.
      i. Stud thread protectors.
      j. Factory painted.
      k. Trim: Polished chrome plated metal cap nuts and washers.
      l. Vandal Resistant Trim: Polished chrome plated metal cap nuts and washers retained with vandal resistant set screws.

G. Urinal Carriers
   1. Floor Mounted Carrier Support (For Wall Hung Urinals): 1-1/4 inch ips steel pipe upright supports with block feet arranged with provisions for bolting to the floor slab, and with the following:
      a. Hanger Plate: Steel, height adjustable with provisions for mounting and positioning the fixture hanger.
      b. Bearing Plate: Steel, adjustable, with bearing studs, nuts and washers.
      c. Studs, Nuts and Washers: Steel, treated for corrosion resistance.
      d. Fixture Washers: Plastic.
      e. Stud thread protectors.
      f. Factory Painted.
      g. Trim: Polished chrome plated metal cap nuts and washers.
      h. Vandal Resistant Trim: Polished chrome plated metal cap nuts and washers retained with vandal resistant set screws.
   2. Floor mounted carrier supports for banks of multiple adjacent fixtures shall have provisions in the support uprights to allow for waste piping to be concealed in the associated wall.Ferrous metal members of carriers and supporting devices with the exception of chrome plated or porcelain enameled cast iron shall be factory painted for corrosion resistance.

## 2.4 SAND / OIL INTERCEPTOR

A. Type: Factory-fabricated interceptor made for removing and retaining sand and oil from wastewater.

B. Body Material: Polyethylene

C. Interior Separation Device: Baffle

D. Inlet and Outlet Size: As noted on drawings

E. Mounting: Below Grade

F. Provide all necessary fittings, manhole access and accessories needed for complete installation.

G. Access: Provide manhole access where installed below concrete. Manhole to be rated for vehicle traffic.

## 2.5 CIRCULATING WATER PUMPS

A. In-Line Pump: Pump to be UL listed & rated to a pressure of 125 PSI at 225 degrees Fahrenheit. Pump shall be a sealed wet rotor design, shaft and bearings shall be ceramic and lubricated by the system fluid. Motor shall be non-overloading with thermal overload protection. Pump volute shall be of stainless steel or bronze suitable for domestic hot water. Refer to the schedule and details on the drawings for additional installation, capacity and construction requirements.

B. Variable Speed In-Line Pump: Pump to be UL listed and rated to a pressure of 125 PSI at 225 degrees Fahrenheit. Pump shall be a sealed wet rotor design. Shaft and bearings shall be ceramic and lubricated by the system fluid. Motor shall be a variable speed permanent-magnet with thermal overload protection. Pump volute shall be of stainless steel or bronze suitable for domestic hot water. Refer to the schedule and details on the drawings for additional installation, capacity and construction requirements.

## 2.6 CLEANOUTS

A. Threaded pipe fitting or cast iron ferrule with gas tight cleanout plug.

B. Plug: Cast brass or bronze, with threaded end, and raised or countersunk head. Tapped head for attachment of cleanout wall or deck plate covers where required.

C. Covers: See Plumbing Material List.

D. Anti-Seize Lubricant: Never-Seez by Bostik Chemical Group, Molycote 1000 by Dow Corning Corp, Anti-Seize Lubricant by Loctite Corp

E. Membrane flange and clamping collar, secured with corrosion resistant fasteners.

## 2.7 AIR GAP FITTINGS

A. Provide when called for in Plumbing Material List.

B. Coated cast iron body with air gaps, set screw or threaded inlet, and outlet connection to match piping option selected.

## 2.8 DRAIN VALVES

A. Provide on all equipment with drain connections and as shown on details.

B. Cast brass body with renewable units, hose bibb vacuum breaker (ASSE 1011) with drainage feature, and removable cast iron handwheel with vandal resistant fastener.
   1. Valve must be completely assembled to make hose connection.
   2. Connections: 1/2 or 3/4 inch threaded or solder end inlet, and 3/4 inch hose bibb outlet.

## 2.9 WATER HAMMER ARRESTERS AND AIR CHAMBERS

A. Provide water hammer arresters as specified on the Plumbing Material List.

B. ANSI A112.26.1; sized in accordance with PDI WH-201, pre-charged for operation between -100º F and 300º F and maximum 250 psig working pressure.

2.11 WALL BOX WITH VALVES

A. Box and faceplate shall be 20 gauge, white powder-coated, cold-rolled steel.

B. The valve shall be brass, quarter-turn, lead-free valve complying with NSF 61, NSF 372, and ASME A112.18.1. Valve shall be marked for identification as lead free.

PART 3 - EXECUTION

3.1 FIXTURE SUPPORT AND SUPPORTING DEVICE INSTALLATION

A. Install heavy duty floor mounted carrier supports with specified fixture supporting devices for wall type plumbing fixtures.
   1. Secure to building construction with lag bolts and metal expansion shields, or other appropriate means as required by the construction encountered.

B. Attach fixtures to floor or wall construction as specified in the Plumbing Material List.

C. Fixture Supporting Devices: Attach fixtures by means of the following fixture supporting devices attached to carrier supports.

| FIXTURE | SUPPORTING DEVICE |
|---|---|
| Lavatory, VC, with back | Concealed arms |
| Lavatory, VC, no back | Concealed arms |
| Lavatory, ECI, with back | Exposed arms |
| Lavatory | Concealed arms |
| Lavatory | Through bolt |
| Water Closet | Bolt to comb. carrier and drainage fitting |
| Urinal | Fixture hanger and bearing plate |
| Water Cooler (wall mounted) | Fixture hanger |
| Water Cooler (Recessed) | Mounting frame |

D. Secure exposed external components in place with vandal resistant fasteners or devices which cannot be removed without the use of special tools.

3.2 FIXTURE INSTALLATION

A. Install the Work of this section in accordance with the manufacturer’s printed installation instructions.

B. See Architectural Floor Plans and Interior Elevation drawings for final installation locations and heights of all plumbing fixtures. Architectural plans supersede these specifications.

C. Install fixtures level and at proper height, tighten connections, and install hold-down bolts, cap nuts and cover plates, where required.

D. Caulk joint between all fixtures and wall or floor with sealant; strike a neat joint.

E. Secure exposed external components in place with vandal resistant fasteners or devices which cannot be removed without the use of special tools.

F. Mop Service Sinks
   1. Set receptor leveled in bed of mortar laid on clean roughened surface. Remove excess mortar and strike a neat joint.
   2. Make connection from drainage pipe to receptor drain.
   3. Install service fittings and miscellaneous trim such as mop hanger and wall protection as called for on Plumbing Material List.

G. Lavatories
   1. Mount lavatories 34 inches from finished floor to rim unless otherwise specified.

H. Countertop Fixtures
   1. Install fixture with securing devices supplied.
   2. Set fixture on bedding of clear sealant, tighten securing devices and remove excess sealant.

I. Water Closets
   1. Wall Hung Fixtures:
      a. Standard Fixtures: Install wall hung fixtures 15 inches from finished floor to rim unless otherwise specified.
      b. Set bearing nuts to position fixture 1/16 inch clear of finished wall.
   2. Floor Supported Fixtures:
      a. Set fixture in bed of setting compound; remove excess.
   3. After connections are tightened, install cap nuts and washers.

J. Urinals
   1. Wall Hung Fixtures
      a. Standard Fixtures: Install wall hung fixtures 24 inches from finished floor to rim.
      b. Set bearing nuts on floor mounted carrier supports to position wall hung fixtures 1/16 inch clear of finished wall.
   2. After connections are tightened, install cap nuts and washers.

K. Flush Valves
   1. Standard Fixtures: Install flush valves on fixture centerline, and at following heights above fixture rim or back to centerline of water inlet to flush valve.
      a. Water Closet: 11-1/2 inches.
      b. Urinal: 11-1/2 inches.
      c. Clinical Sink: 24 inches.

2. Handicapped Accessible Fixtures: Install flush valves on fixture centerline, and at following height above finished floor to centerline of flush valve operator. Distance between centerline of flush valve operator and centerline of water inlet is 1-1/2 inches.
   a. Water Closet: Approximately 31-1/2 inches, and mounted on wide side of stall.
      1) Coordinate mounting height with General Contractor to avoid interference with grab bar, and to facilitate flush valve servicing.
   b. Urinal: Maximum 44 inches.
3. Slip joints in flush pipe connections allowed only at fixture spud and vacuum breaker ends; others shall be screwed connections.
4. Score tubing ends before assembling to assure tight slip joint connections. No score marks shall be visible after assembly.
5. In utility corridors, solder screwed flush pipe connections.

L. Floor drains
1. Install the Work of this section in accordance with the manufacturer's printed installation instructions, unless otherwise specified.
2. Protect weep holes from plugging during installation. Rod out weep holes after installation to remove obstructions.
3. Set drainage flange flush with top of structural floor slab, or at elevation otherwise indicated.
4. After membrane waterproofing installed and cured, secure clamping ring.
5. Adjust strainer head to height indicated. If height not indicated, set at 1/2 inch below finished floor elevation.

M. Drains and Inlets During Construction
1. Provide a temporary cover for all floor, roof, trench and area drains during construction to prevent debris getting into the system and protect drain grates. Remove temporary covers and clean grates at the end of construction.
2. The contractor is responsible for the flushing of all drains used during construction. This includes main and branch lines. If solids or debris in the system result in flow issues, the contractor will be required to camera and remove obstructions.

N. Wall Hydrants: Installation Height: Minimum 18 inches above finished grade.

O. Cleanout Plug: Lubricate threads with anti-seize lubricant before final installation.

P. Water Hammer Arresters
1. Install water hammer arresters in accessible locations. Provide access doors as required. Coordinate type with Architect/Owner.

Q. Wall Boxes
1. Coordinate installation height and required millwork openings with architectural plans and millwork submittals.

## 3.3 PUMP INSTALLATION

A. Install in-line circulating pumps between pipe flanges in piping systems. Install overhead pipe supports, both sides of in-line pumps, installed in horizontal piping runs.

3.4 CLEANING, FLUSHING AND ADJUSTMENT

A. Clean fixtures and trim. Remove grease and dirt; polish surfaces but leave stickers and warning labels intact.

B. Flush supply piping and traps; clean strainers.

C. Adjust stops for proper delivery.

**END OF SECTION**

**SECTION 226713**

**HIGH PURITY WATER SYSTEMS (RO)**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the Reverse Osmosis (RO) System indicated by the Contract Documents. Provide all supplementary items necessary for proper installation.

B. The water conditioning system/supplier shall be totally responsible for the supply and installation of the water treatment system to include the central RO water system.

C. Provide an RO system with capacities and electrical characteristics as scheduled on Contract Drawings. Scheduled gallons per day (24 hour period) shall be based on a feed water temperature of 60° F.

1.2 REFERENCES

A. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
   1. Adopted version of the Florida Plumbing Code
   2. Underwriters Laboratories Listings.
   3. Adopted version of the National Electric Code
   4. ASME - Boiler and Pressure Vessel Code.
   5. ASTM D 3222 - Standard Specifications for Unmodified PVDF molding material.
   6. ASTM D 638 - Standard Test Method for Tensile Properties of Plastic.
   7. ASTM D 790 - Standard Test Method of Flexural Properties of Unreinforced and Reinforced Plastics and Electric Insulating Materials.

1.3 SUBMITTALS

A. Product Data
   1. Code and Standards compliance, manufacturer's data for pipe, fittings, valves, controls, water testing kits. and all furnished specialties, and accessories.
   2. Include rated pressures, temperatures, capacities and operating characteristics.
   3. Manufacturer’s installation instructions.
   4. Shop Drawings: Include plans, elevations, sections, details, and connections to piping systems. Indicate size, profiles, and dimensional service requirements of system based on the specific components being installed.
   5. Source and Site quality-control test reports.
   6. Operation and Maintenance Data

1.4 QUALITY ASSURANCE

A. Company shall have minimum three (3) years documented experience specializing in performing the work of this section.

1.5 DELIVERY, STORAGE AND HANDLING

A. Accept delivery of packaged high purity water equipment, storage vessel, etc. on Site in factory fabricated containers with shipping skids and pipe end protectors in place. Inspect for damage. Comply with manufacturers rigging and installation instructions.

B. All components and materials shall be new, undamaged, and free of rust.

C. Provide temporary protective coating and end plugs on valves not packaged within containers. Maintain in place until installation.

D. Provide temporary end caps and closures on openings, connections, pipe and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work and isolating parts of completed system.

F. Protect all components and materials that are to be installed within this project from exposure to rain, freezing temperatures and direct sunlight. EXCEPTION: Materials manufactured for exterior locations.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 PIPING, VALVES AND FITTINGS

A. Reverse Osmosis Systems:
   1. Pipe, valves and fittings from the reverse osmosis unit to include the supply and return building loop system shall be one of the following materials as noted in the Plumbing Piping Application Schedule in the construction documents:
      a. SYGEF flame resistant, self-extinguishing polyvinylidene fluoride (PVDF) (SDR-11 through SDR-21 or pipe schedule equivalent) with heat fusion socket connections.

b. Polypropylene (PP) Schedule 40 with heat fusion socket or buttweld connections. Material from which pipe, fitting and valves are manufactured shall conform to the standards of ASTM F 2389. PP piping shall be insulated to provide ASTM E84 ratings.
c. Stainless Steel (type 304 or 316) Schedule 10 with threaded connections.

## PART 3 - EXECUTION

### 3.1 CLEANING AND DISINFECTION

A. Semi-conductor grade 35 percent unstabilized hydrogen peroxide diluted to 5 percent with deionized water shall be used as the disinfectant. Sodium hypochlorite is not acceptable. Hydrogen peroxide disinfection solution shall be placed in storage tanks, pumped through 0.2-micron absolute membrane filters and into the pvdf piping system. All valves and sample ports shall be opened to purge distribution lines of gases.

B. Hydrogen peroxide solution shall be recirculated for 24 hours. Outlets and sample ports shall be opened and closed each six (6) hours for two (2) minutes. At the end of the 24-hour recirculation period, valves and sample ports shall be opened and system shall be drained. Flush system with deionized water. At the completion of the disinfection process, the ro system and di water system shall be online with equipment ready for operation and distribution piping system in the recirculation mode.

### 3.2 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer’s published recommendations.

### 3.3 START-UP AND SERVICE

A. Make available the service of qualified personnel to supervise the installation and start-up of the entire system. Provide qualified personnel to train owner maintenance and operations personnel in the maintenance and operation of the entire system. Provide a minimum of two (2) hours of owner training. When start-up is complete and the system is operational, notify owner that the acceptance test will be started. Provide all chemicals, filters and expandable materials necessary to perform start-up service. Provide necessary chemical test kits as required by maintenance manuals in corrosion-resistant metal cabinet mounted on wall.

3.4 TESTING

A. Test the system under design operating conditions for a period of 24 hours and check for leaks. After all leaks have been repaired, retest the system until proven airtight.

**END OF SECTION**

**SECTION 230500**

**HVAC COMMON WORK RESULTS**

PART 1 - GENERAL

1.1 SCOPE

A. The work under this section includes basic mechanical requirements, which are applicable to all Division 21, 22 and 23 sections.

B. Overview of work
   1. HVAC
   2. Plumbing
   3. Fire Protection
   4. Commissioning

C. In these documents, "Contractor" refers to the mechanical contractor and all their subcontractors, unless listed otherwise. The division of work within the mechanical scope is the responsibility of the lead mechanical contractor.

D. Contractor is responsible for providing fully functional systems.

E. If work is shown on the drawings or listed in the specifications, it shall be included by the Contractor.

F. If equipment is provided by the Contractor, it shall be installed by the Contractor, unless noted otherwise.

G. The drawings are necessarily diagrammatic by their nature and are not intended to show every connection in detail or every item in its exact location. Carefully investigate structural and finish conditions and coordinate the separate trades in order to avoid interference between the various phases of Work. Organize and lay out Work so that it will be concealed in furred chases and suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. Install all Work parallel or perpendicular to building lines unless otherwise noted.

H. The intent of the Drawings is to establish the types of systems and functions; not to set forth each item essential to the functioning of the system. Install the Work complete, including minor details necessary to perform the function indicated. Review pertinent Drawings and adjust the Work to conditions shown. Where discrepancies occur between Drawings, Specifications, and actual field conditions, immediately notify the Architect and Engineer for interpretations.

I. All sizes as given are minimum except as noted.

J. Materials shall be new (unless noted or stated otherwise), first class, and workmanlike, and shall be subject at all times to the Architect's, Engineer's, and Owner's observations from the commencement until the acceptance of the completed work.

K. Owner Furnished Equipment
   1. The following items are provided by the Owner and installed by the contractor:
      a. Refer to plans.
   2. The following items are provided and set in place by the Owner. Contractor to make final utility connections.
      a. Refer to plans.

1.2 REFERENCES

A. Applicable provisions of Division 0 and Division 1 govern work under this Section.

B. All work shall conform to the most current version of all applicable codes and standards or the version adopted by the jurisdiction.

C. Codes
   1. International Building Code
   2. International Mechanical Code
   3. Florida Plumbing Code
   4. International Fuel Gas Code
   5. International Fire Protection Code
   6. International Energy Conservation Code
   7. NFPA – National Fire Protection Association
   8. State or City Codes for the City of Pensacola, FL
   9. Florida Building Code – Fuel Gas

D. Standards
   1. ASHRAE Standard 15
   2. ASHRAE Standard 62
   3. ASHRAE Standard 90.1
   4. SMACNA – Sheet Metal and Air Conditioning Contractors National Association, Inc.
   5. AMCA – Air Movement and Control Association
   6. ASME – American Society of Mechanical Engineers
   7. ANSI – American National Standards Institute
   8. ARI – Air Conditioning and Refrigeration Institute

E. Governing Bodies
   1. Owner's Insurance Company
   2. State Fire Marshal
   3. AHJ – Authority Having Jurisdiction
   4. UL - Underwriters Laboratories

1.3 SUBMITTALS

A. The review of shop drawings by the Engineer is for general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. Corrections or comments made on the shop drawings during this review do not relieve the contractor from compliance with the requirements of the plans and specifications.

Approval of a specific item shall not include approval of an assembly of which the item is a component. The Contractor is responsible for: dimensions to be confirmed and correlated at the jobsite; information that pertains solely to the fabrication processes or to the means, methods, techniques, sequences and procedures of construction; coordination with the Work of all trades; and for performing all work in a safe and satisfactory manner.

B. Refer to individual technical specification sections for specific submittal requirements.

C. Submission of shop drawings electronically In .PDF format is preferred.

D. If hard copies of shop drawings are utilized on this project, coordinate the quantity with the Architect and General Contractor. Provide one (1) copy for the Engineer's records.

E. The Engineer will review one resubmittal for each product. If additional resubmittals are required, the Contractor shall be responsible to bear the cost for the Engineer to recheck and handle the additional shop drawing submittals. Documents will not be reviewed until payment is agreed upon.

F. Contractor may request electronic AutoCAD files from the Engineer if needed to complete their shop drawings. An Electronic File Request Form will be sent to the contractor if files are requested and must be completed and signed before the AutoCAD files are released to the Contractor.

G. All submittals for equipment and materials shall be reviewed and approved by the engineer prior to the fabrication or release by the contractor. This includes fabrication drawings for ductwork and fire protection and the coordination of equipment between trades. The release, purchase, installation or fabrication of any items prior to the contractor receiving an approved shop drawing will be at the contractor's own risk. Any rework that results will be provided by the contractor at no cost to the Owner or design team.

H. Submittals must be reviewed and approved by the Contractor before submitting to the Engineer.

I. 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.

## 1.4 QUALITY ASSURANCE

A. Warranty
   1. Equipment warranty shall be a minimum of one (1) year from date of factory supervised startup or from the date of substantial completion, whichever is later.
   2. Contractor shall warranty all of their work for one (1) year from the date of substantial completion.

B. Equipment Capacity
   1. All equipment submitted shall meet or exceed the capacity listed in the specifications and schedules. This includes airflows / static pressure, heating / cooling capacities, pump flow / head, and all values listed in the construction documents.

2. All submitted motor brake horsepower's submitted shall be at least 5% less than the rated nominal motor horsepower. No motors shall be selected in the motor service factor with the exception of fire pumps.
3. The mechanical contractor shall be responsible for any structural, electrical, piping, ductwork or other utility modifications resulting from an alternate manufacturer than the basis of design being used.

C. These documents are diagrammatical in nature and intended to convey scope and general arrangement of the mechanical systems. Not all fittings, risers, size changes, offsets, valves, accessories, etc. are shown on plan. If items are required to make a system fully operational but not shown on plan or in these specifications, they shall be included by the contractor.

D. The intent of the Drawings is to establish the types of systems and functions; not to set forth each item essential to the functioning of the system. Install the Work complete, including minor details necessary to perform the function indicated. Review pertinent Drawings and adjust the Work to conditions shown. Where discrepancies occur between Drawings, Specifications, and actual field conditions, immediately notify the Architect and Engineer for interpretations.

E. It is the contractor's responsibility to determine all utility routing prior to purchase and installation of material.

F. The contractor shall report any discrepancies between these documents and site conditions immediately to the Engineer prior to submitting a bid or starting work. Submittal of a bid indicates that the contractor and the contractor's subcontractors have carefully and thoroughly reviewed the drawings, specifications, and other construction documents and have found them complete and free from ambiguities and sufficient for the purposes intended.

G. Install all equipment per the manufacturer's requirements / recommendations.

H. No equipment provided or installed shall contain mercury.

I. Manufacturer Supplier Inspection & Startup
   1. The following equipment shall have a factory representative perform start-up. The procedure shall be documented and submitted to the design team and Owner. Include copies of startup reports in the Operations & Maintenance Manuals.
      a. Division 22
         1) Reverse Osmosis Systems
         2) Water Softeners
      b. Division 23
         1) Air Handling Units
         2) Fuel Oil System

J. All equipment shall be UL listed where applicable.

## 1.5 ELECTRONIC DOCUMENT RELEASE

A. Electronic versions of the bid documents will be made available to the contractors for use during the bidding process and to help generate fabrication drawings for various systems. A summary of the requirements for the various document types is listed below:
   1. PDF
      a. Contact the Construction Manager or Architect to obtain a PDF version of the Bid Documents. No Document Release Form is required.
   2. AutoCAD
      a. KEDbluestone Engineering can provide an AutoCAD version of the bid documents for the contractor to use for generating shop drawings and fabrication drawings. This will include plan drawings with the architectural background. The contractor is responsible for incorporating any modifications that occur during bidding by all disciplines. Details and schedules will not be included.
      b. A document release form (see attached) will be required to be completed by the contractor to determine the version of AutoCAD and drawings required. No fee is associated with these drawings.
   3. REVIT
      a. The REVIT drawings will be converted to AutoCAD and then transferred to the contractor.
      b. KEDbluestone Engineering can provide an AutoCAD version of the bid documents for the contractor to use for generating shop drawings and fabrication drawings. This will include plan drawings with the architectural background. The contractor is responsible for incorporating any modifications that occur during bidding by all disciplines. Details and schedules will not be included.
      c. A document release form (see attached) will be required to be completed by the contractor to determine the version of AutoCAD and drawings required.
      d. Submittal of the document release form will be required prior to the AutoCAD files being transmitted.

## 1.6 SUBSTITUTIONS

A. All manufacturers listed as Acceptable Manufacturers in each specification section are considered equal to the basis of design. The basis of design is preferred and will take precedence. Any products from an alternate approved manufacturer need to meet the requirements and performance specified and shall be equal to the basis of design.

B. The Contractor may request permission for a substitution of any item (equipment or material), subject to the following conditions:
   1. Submit substitution requests in writing to the Engineer, on a form supplied by the Engineer. A sample copy of this form is included at the end of this section. An electronic copy can also be provided to the Contractor by the Engineer.
   2. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contractor documents, the Contractor is responsible for all costs involved in integrating the equipment or accessories into the system and the assigned space and for obtaining the performance from the system into which these items are placed as well as any re-design

costs incurred by the Architect or Engineer. The Contractor is also responsible for coordinating changes required by other trades.

3. Any requests for alternate manufacturers must be submitted to the Architect/Engineer at least ten (10) days prior to bid day. Incomplete substitution requests will not be considered.

C. Approval
   1. No work involving requests for substitution shall commence without written approval on the provided form by the Engineer.
   2. Any work started or material ordered/installed by the Contractor without written approval shall be removed/repaired at the sole expense of the contractor. The Contractor will also be responsible for any costs incurred by the Owner for such rework.

## 1.7 COORDINATION DRAWINGS

A. The mechanical contractor shall be responsible for producing coordination drawings. The drawings will need to incorporate piping, ductwork, equipment, lighting, conduits, building structure and all other building and system components that will need to be coordinated for proper systems installation and operation.

B. The drawings will be 1/4" scale.

C. Coordination meetings will be conducted on site with all concerned contractors present. Representatives from the Engineer will also be present to review conflicts and approve contractor variations to the contract documents.

## 1.8 REGULATORY AND UTILITY REQUIREMENTS

A. Contractor is responsible for coordinating all required site inspections by authorities having jurisdiction. Contractor shall notify General Contractor of all scheduled inspections seven (7) working days prior to site visit.

B. Contractor is responsible for paying for all fees, permits, and inspections that are required to complete their work.

C. Contractor shall include all work required to relocate utilities and meters as shown on drawings.

D. Contractor shall include all work required to install new utilities and meters as shown on drawings. This includes any new service and meter fees in coordination with the utility company.

E. Utility work 5’-0” from outside of building is by others.

1.9 PROTECTION OF FINISHED SURFACES

A. Furnish one (1) can of touch-up paint for each different color factory finish for equipment furnished by the Contractor. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

1.10 SEALING AND FIRESTOPPING

A. Sealing and firestopping of sleeves/openings between ducts and piping 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.

1.11 WORK BY OWNER AND/OR OWNER AGENCY

A. Asbestos abatement, removal and disposal, if required, will be by the Owner under separate contract.

1.12 OMISSIONS

A. No later than ten (10) days before bid opening, the Contractor shall call the attention of the Architect and Engineer to any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

1.13 DELIVERY, STORAGE, AND HANDLING

A. All equipment and materials shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.

B. Store equipment indoors in clean dry space with uniform temperature to prevent condensation or damage from the elements.

C. Take such precautions as are necessary to protect apparatus and materials from damage. Damaged equipment shall be, as determined by the Owner and/or Engineer, placed in first class operating condition or be returned to the source of supply for repair or replacement.

D. Protect factory finish from damage during construction operations until acceptance of the Project. Restore any finishes that become stained or damaged to Owner’s satisfaction.

1.14 DIVISION OF WORK AND COORDINATION

A. The Electrical Contractor is responsible for providing and installing power wiring up to equipment provided by others for a single point connection. Internal wiring of equipment

provided by others shall be the responsibility of the contractor responsible for providing and installing the equipment.

B. Controls, disconnect switches, starters, variable frequency drives, etc. shall be provided and installed by the contractor noted on the plans and in the specifications. It is the responsibility of the Contractor to request written clarification for any ambiguity regarding division of work and coordination at least ten (10) days prior to bid.

C. See Section 230900 for scope of wiring required for Temperature Control systems.

D. Utilities routed within the building shall be installed in an orderly manner. All work will be coordinated with other disciplines prior to installation. The following list ranks the priority of the utilities to be installed:
   1. Light fixtures
   2. Gravity piping
   3. Electrical busduct
   4. Ductwork
   5. Cable tray
   6. All other piping
   7. Electrical conduits

E. 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.

F. Coordinate work with the Testing and Balancing (TAB) Contractor. Verify system completion to the TAB Contractor such as pressure testing, chemical treatment, filling of liquid systems, proper pressurization and air venting of hydronic systems, clean filters, clean strainers, controls adjusted and calibrated, fire/smoke damper integration ready for testing, adjusting and balancing work. Install dampers, shutoff and balancing valves, flow measuring devices, gauges, temperature controls, etc., required for functional and balanced systems. Assist the TAB Contractor as needed to complete their work.

G. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

H. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

I. 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."

## 1.15 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

B. In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation as applicable:
   1. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
   2. A control sequence describing start-up, operation, and shutdown.
   3. Description of the function of each principal item of equipment.
   4. Installation instructions.
   5. Safety precautions for operation and maintenance.
   6. Diagrams and illustrations.
   7. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers and replacement frequencies.
   8. Performance data.
   9. Where applicable, pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare parts, and name of servicing organization.
   10. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.

## 1.16 RECORD DRAWINGS

A. The Contractor shall maintain at least one copy each of the Specifications and Drawings on the job site at all times.

B. The Architect will provide the Contractor with a suitable set of Contract Drawings on which daily records of changes and deviations from contract shall be recorded. Dimensions and elevations on the record drawings shall locate all buried or concealed piping, conduit, or similar items.

C. The daily record of changes shall be the responsibility of Contractor's field superintendent. No arbitrary mark-ups will be permitted.

D. At completion of the project, the Contractor shall submit the marked-up record drawings to the General Contractor prior to final payment.

## 1.17 SPECIAL REQUIREMENTS

A. Contractor bid shall allow color selection by Architect of any piece of exposed equipment from all available colors. Base bid color selection shall include those considered ‘premium’ by the manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL

A. Conditions: Provide new products of manufacturers regularly engaged in production of such equipment. Provide the manufacturer's latest standard design for the type of product specified.

2.2 ACCESS PANELS AND DOORS

A. Provide access panels and/or doors where required to maintain access to the electrical installation and where noted on the Drawings.

B. Lay-in Ceilings
   1. Removable lay-in ceiling tiles in 2 x 2 foot or 2 x 4 foot configuration provided under other divisions are sufficient; no additional access provisions are required unless specifically indicated.

C. Plaster/Gypsum Walls and Ceilings
   1. 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".

2.3 SEALING AND FIRESTOPPING

A. Fire and/or Smoke Rated Penetrations
   1. Manufacturers
      a. 3M, STI/SpecSeal, Tremco, Hilti or approved equal.
   2. All firestopping systems shall be by the same manufacturer.
   3. 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.
   4. Product
      a. Firestop systems shall be UL listed or tested by an independent testing laboratory approved by the Department of Commerce.
      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 wrap strips, intumescent fire stop collars, fire stop 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.

B. Non-Rated Penetrations
   1. Piping 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 piping and the cored opening or a water-stop type wall sleeve.
   2. Piping and Ductwork Penetrations
      a. At penetrations of non-rated interior partitions, floors and exterior walls above grade, use urethane caulk in annular space between pipe/duct and sleeve or opening.

## 2.4 PAINT

A. For indoor applications, use paints and primers that have a VOC content of 250 g/L or less when calculated according to the adopted version of the Green Seal Standard GC-03, Anti-Corrosive Paints.

# PART 3 - EXECUTION

## 3.1 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. 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. Extend grease fittings to accessible locations

D. Install equipment to allow right of way for piping installed at required slope.

E. Provide clearance for inspection, repair, replacement, and service to all equipment to include a minimum of 36 inches from all obstructions (walls, structure, ductwork, pipes, etc.). Clearance shall maintain access to all electrical panels, access doors, controllers, valves, junction boxes and operators and include the area directly in front of and above the system components.

## 3.2 EXCAVATION AND BACKFILL

A. Perform all excavation and backfill work to accomplish indicated mechanical systems installation in accordance with Section 312316.13 - Trenching.

## 3.3 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 not less than 4 inches larger in both directions than supported unit.
   2. All pads to be a minimum of 4” thick unless noted otherwise. Thicken pads as needed to accommodate the slope of slab / grade around the equipment.Exterior pads installed on grade to include frost footings. Coordinate requirements with the civil / structural designers. Refer to equipment schedules for additional requirements. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
   6. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   7. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   8. Install anchor bolts to elevations required for proper attachment to supported equipment.
   9. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   10. Indoor or outdoor equipment meeting any or all of the following requirements shall be installed on housekeeping pads:
      a. Floor mounted motorized equipment.
      b. All floor or ground mounted air handling equipment and fans.
      c. All heating, cooling, plumbing, and fire protection equipment and associated floor mounted accessories located in mechanical spaces.
      d. Equipment installed in areas with uneven surfaces and surfaces that are not level.
      e. As required by the equipment manufacturer
   11. Refer to plans and details for additional pad locations.

## 3.4 PAINTING

A. Exposed piping in occupied areas to be painted by others. Coordinate color with architect.
   1. Contractor to prep duct and piping as needed to accept paint.

B. Contractor shall paint the following items with two (2) coats of exterior enamel over one (1) coat primer. Select paint to be compliant with material being used, i.e. metal, plastic, etc:
   1. All exposed duct, hydronic, and natural gas piping. Color to be coordinated with the Architect.

## 3.5 SEALING AND FIRESTOPPING

A. Fire and/or Smoke Penetrations
   1. Install approved product in accordance with the manufacturer's instructions where a pipe/duct 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.

B. 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.
   2. Install escutcheons or floor/ceiling plates where pipe/duct 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 pipe/duct 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, pipe/duct penetrations are required to be sealed for all clean rooms, laboratories, and most hospital spaces, computer rooms, dormitory rooms, telephone/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 sleeve and the pipe/duct is completely filled.

## 3.6 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.

## 3.7 SITE OBSERVATIONS

A. Site observations shall be performed by the Engineer at the following project milestones:
   1. Prior to enclosure of the following areas:
      a. Walls and chases
      b. Above the ceiling
   2. Final project completion

B. Contractor shall provide seven (7) working days' notice to Engineer prior to site visit.

C. The Engineer is only responsible to conduct one (1) final site visit. If upon visiting the site, the Engineer finds that not enough work is complete for the final site visit, the Contractor shall be responsible to bear the cost for the Engineer to travel to the site and revisit. Revisiting will not occur until payment is agreed upon.

## 3.8 EQUIPMENT STARTUP

A. Contractor shall provide startup of equipment by factory certified personnel for equipment listed above.

B. For all other equipment, Contractor shall perform startup per manufacturer's requirements. Startup shall be performed by personnel qualified for this work.

C. Contractor shall test equipment to be fully functional. Test all equipment safeties and emergency stops. Test all control set-points and equipment modes.

D. Contractor shall return to site as needed to adjust equipment for seasonal equipment performance changes.

## 3.9 OWNER TRAINING

A. Contractor shall include at least eight (8) hours for each maintenance staff shift group in their bid to provide complete Owner training for all the mechanical systems. Training shall include explanation of system operation, startup/shutdown, routine maintenance, seasonal changes, and controls adjustments. Coordinate acceptable training schedule with Owner.

B. All training provided for the Owner shall comply with the format, general content requirements and submission guidelines specified under Section 019101, or 019102.

C. Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of (4) hours or for the duration noted in the technical Specifications.

## 3.10 PROJECT CLOSEOUT REQUIREMENTS

A. Final project closeout tasks
   1. Deliver all spare parts listed in each specification section. Deliver to Owner chosen location.
   2. All equipment labeled per specifications.
   3. All equipment cleaned and ready for use. Install new filters in all equipment with filters; do not use Owner's spare filter sets.

B. Contractor requirements
   1. Marked up drawings and specifications provided to Engineer for incorporation of as-built drawings or to serve as the as-built drawings depending on the project requirements. As-built drawings shall be clean and legible.
   2. Operation and Maintenance (O & M) Manuals shall include the following:
      a. Contractor contact for warranty work
      b. Approved shop drawings, incorporating all review comments
      c. Warranty copies
      d. Equipment start-up reports
      e. Testing and balancing reports
      f. Operation and maintenance instructions
   3. Utility Rebate Forms
      a. Contractor shall submit completed energy rebate forms for each piece of equipment that is eligible for a rebate. Eligible equipment shall include, but not be limited to the following:
         1) Split System Air Conditioners
         2) Rooftop Air Conditioning Units

3) Building Automation System
4) Motors
5) Variable Frequency Drives

b. Contractor to complete information regarding equipment. Submit form to Owner, Owner will complete Owner's contact information and send the completed form to the utility.

4. Three (3) final approved O & M Manuals shall be delivered to Owner. Each manual shall be an appropriately sized three (3) ring binder with a vinyl cover and printed spine and cover labels. Each section shall have a printed divider tab. Each section shall be listed in a table of contents at the beginning of the manual.

**END OF SECTION**

(ELECTRONIC DOCUMENT RELEASE FORM & SUBSTITUTION REQUEST FORMS ATTACHED)

**Document Release Form**

**Information Requested:**

| |
|---|
| Project Name: |
| Drawings Requested: |
| |
| |

**Media Type:** (Check all that are applicable)

- ☐ AutoCAD DWG Files (Version _____)
- ☐ REVIT Files (Version _____)
- ☐ Adobe PDF Files
- ☐ Other

**Requesting Party:**

Name:

Company:

Signature:

Date:

Address 1:

Address 2:

Email Address:

Phone #:

**KEDbluestone Use:**

Form Sent By:

Date:

KEDbluestone Project #:

Data contained on these electronic files are part of our instruments of service and shall not be used by you or anyone else receiving these data through or from you for any purpose other than as a convenience in the preparation of shop drawings for the referenced project. Any other use or reuse by you or by others will be at your sole risk and without liability or legal exposure to us. You agree to make no claim and hereby waive, to the fullest extent permitted by law, any claim or cause of action of any nature against us, our officers, directors, employees, agents or sub consultants that may arise out of or in connection with your use of the electronic files. Furthermore, you shall, to the fullest extent permitted by law, indemnify and hold us harmless against all damages, liabilities or costs, including reasonable attorneys' fees and defense costs, arising out of or resulting from your use of these electronic files. These electronic files are not construction documents. Differences may exist between these electronic files and corresponding hard-copy construction documents. We make no representation regarding the accuracy or completeness of the electronic files you receive. In the event that a conflict arises between the signed or sealed hard-copy construction documents prepared by us and the electronic files, the signed or sealed hard-copy construction documents shall govern. You are responsible for determining if any conflict exists. By your use of these electronic files, you are not relieved of your duty to fully comply with the contract documents, including, and without limitation, the need to check, confirm and coordinate all dimensions and details, take field measurements, verify field conditions and coordinate your work with that of other contractors for the project. Because information presented on the electronic files can be modified, unintentionally or otherwise, we reserve the right to remove all indicia of ownership and/or involvement from each electronic display.

**SUBSTITUTION REQUEST FORM (DURING BIDDING)**

We submit for your consideration the following product instead of the specified item for the following project:

PROJECT: _____

| SPEC. SECTION | SPEC. TITLE | PARAGRAPH | SPECIFIED ITEM |
|---|---|---|---|
| _____ | _____ | _____ | _____ |

Proposed Substitution: _____

| MANUFACTURER | TRADE NAME | MODEL NO. |
|---|---|---|
| _____ | _____ | _____ |

Attached data includes product description, specifications, drawings, photographs, and performance and test data adequate for evaluation of the request; applicable portions of the data are clearly identified.

Attached data also includes a description of changes to the Contract Documents that the proposed substitution will require for its proper installation.

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The Undersigned certifies:

- Proposed substitution has been fully investigated and determined to be equal or superior in all respects to specified product.
- Same warranty will be furnished for proposed substitution as for specified product.
- Same maintenance service and source of replacement parts, as applicable, is available.
- Proposed substitution will have no adverse effect on other trades and will not affect or delay progress schedule.
- Proposed substitution does not affect dimensions and functional clearances.
- Payment will be made for changes to building design, including Architectural and Engineering design, detailing, and construction costs caused by the substitution.

Submitted by:

_____
Signature

_____
Firm

_____

Telephone Email Date

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Engineer's Review and Action

☐ Substitution Approved
☐ Substitution Approved As Noted
☐ Substitution Rejected
☐ Substitution Request Received Too Late

Signed by:

_____

Date

Supporting Data Attached:

☐ Drawings ☐ Product Data ☐ Samples ☐ Tests ☐ Reports ☐ Other _____

**SECTION 230529**

**PIPE HANGERS AND SUPPORTS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Pipe Hangers and Supports indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Refer to Section 230719, PIPING INSULATION for work related to this section.

1.3 SUBMITTALS

A. Product Data
   1. Manufacturer's catalog sheets and specifications for hangers and supports materials.
   2. Installation instructions.
   3. Schedule indicating what type of hangers or support will be used for various piping types.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with the applicable requirements of the ASME B31 Piping Codes.
   2. Unless otherwise shown or specified, comply with the requirements of the Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS) Standards SP-58, and SP-69.
   3. Materials for use in Sprinkler Systems and Standpipe and Hose Systems shall comply with the requirements of NFPA 13 and NFPA 14 as applicable.
   4. Hang and support cast iron soil pipe and fittings in accordance with the recommendations of the Cast Iron Soil Pipe's Institute's (CISPI) Cast Iron Soil Pipe and Fittings Handbook.

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Combination clevis hanger, pipe insulation shield and vapor barrier jacketed high density insulating saddle with companion high density filler piece.

1. Insulating saddles and filler pieces shall be of the same thickness and materials as the adjoining pipe insulation. Saddles shall cover the lower 180 degrees of the pipe or tubing, and companion filler pieces shall cover the upper 180 degrees of the pipe or tubing. Physical sizes, gages, etc. of the components of insulated hangers shall be in accordance with the following schedule:

| PIPE OR TUBING SIZE (Inches) | SHIELD LENGTH (Inches) | SHIELD GAUGE | SADDLE LENGTH (Inches) | VAPOR BARRIER JACKET LENGTH (Inches) |
|---|---|---|---|---|
| Up to 2-1/2 | 4 | 16 | 6 | 10 |
| 3 to 6 | 4 | 14 | 6 | 10 |
| 8 to 14 | 10 | 12 | 12 | 16 |
| 16 and up | 10 | 10 | 12 | 16 |

B. Pipe Insulation Shields: Fabricated of steel, with a minimum arc of 180 degrees, unless otherwise indicated. Shields for use with hangers and supports, with the exception of combination clevis type hangers, shall be in accordance with the following schedule:

| PIPE OR TUBING SIZE (Inches) | SHIELD LENGTH (Inches) | SHIELD GAUGE |
|---|---|---|
| Up to 2-1/2 | 8 | 18 |
| 3 to 8 | 10 | 16 |
| 10 to 14 | 12 | 12 |
| 16 and up | 18 | 10 |

C. Pipe Hangers: Height adjustable standard duty clevis type, with cross bolt and nut.
   1. Pipe spreaders or spacers shall be used on cross bolts of clevis hangers, when supporting piping ten (10) inches in size and larger.
   2. Swivel ring type hangers will be allowed for sprinkler piping up to a maximum of two (2) inches in size.

D. Adjustable Floor Rests and Base Flanges: Steel.

E. Hanger Rods: Mild, low carbon steel, fully threaded or threaded at each end, with two (2) nuts at each end for positioning rod and hanger, and locking each in place.

F. Riser Clamps: Malleable iron or steel.

G. Rollers: Cast Iron.

H. Specialty: Fasteners, supports and hangers for PEX piping shall be specifically designed for PEX piping.

2.2 ANCHORS AND ATTACHMENTS

A. Sleeve Anchors (Group II, Type 3, Class 3): Molly's Div./USM Corp. Parasleeve Series, Ramset's Dynabolt Series, or Red Head/Phillips AN, HN, or FS Series.

B. Wedge Anchors (Zinc Plated, Group II, Type 4, Class 1): Hilti's Kwik Bolt Series, Molly's Div./USM Corp. Parabolt PB Series, Ramset's Trubolt T Series, or Red Head/Phillips WS Series.

C. Self-Drilling Anchors (Group III, Type 1): Ramset's RD Series, or Red Head/Phillips S Series.

D. Non-Drilling Anchors (Group VIII, Type 1): Ramset's Dynaset DS Series, Hilti's HDI Series, or Red Head/Phillips J Series.

E. Stud Anchors (Group VIII, Type 2): Red Head/Phillips JS Series.

F. Beam Clamps: Forged steel beam clamp, with weldless eye nut (right hand thread), steel tie rod, nuts, and washers, Grinnell's Fig No. 292 (size for load, beam flange width, and rod size required).

G. Metal Deck Ceiling Bolts: B-Line Systems' Fig. B3019.

H. Continuous Slotted Type Concrete Insert, Galvanized.

I. Threaded Type Concrete Insert: Galvanized ferrous castings, internally threaded to receive 3/4 inch diameter machine bolts.

J. Wedge Type Concrete Insert: Galvanized box-type ferrous castings, designed to accept 3/4 inch diameter bolts having special wedge shaped heads.

2.3 FASTENERS

A. Bolts, Nuts, Washers, Lags, and Screws: Medium carbon steel; size and type to suit application; galvanized for high humidity locations, and treated wood; plain finish for other interior locations. Except where shown otherwise on the Drawings, furnish type, size, and grade required for proper installation of the Work.

2.4 SHOP PAINTING AND PLATING

A. Hangers, supports, rods, inserts and accessories used for pipe supports, unless chromium plated, cadmium plated or galvanized shall be shop coated with metal primer paint. Electroplated copper hanger rods, hangers and accessories shall be used when hangers are in direct contact with copper pipe or copper tubing.

B. Hanger supports for chromium plated pipe shall be chromium plated brass.

## 2.5 ROOFTOP SUPPORT SYSTEMS

A. Rooftop supports for piping equipment shall be provided for installation without requiring roof penetrations, flashing, or damage to the roofing material. Height-adjustable supports may be used where necessary. Support piping a minimum of 4" above the roof surface.

B. Materials:
   1. Support bases shall be made of an engineered material with appropriate additives for UV protection. All structural steel components shall be hot-dipped galvanized.
   2. The support shall have a continuous bottom surface to provide even load distribution and minimize point loading of the roof membrane. The support base will have a radiused edge to enhance compatibility with roof membranes.
   3. Coordinate static load rating of the support(s) with the specific application being served.
   4. Accessories: Clamps, bolts, nuts, washers, and other devices as required for a complete system.

C. Applications:
   1. Fixed Strut Pipe Hanger Supports: Size and load ratings for the application
   2. Adjustable Strut Pipe Hanger Supports: Height adjustable, size and load ratings for the application
   3. Adjustable Single Piping Supports: Height adjustable, size and load ratings for the application
   4. Block Supports: Size and load ratings for the application
   5. Roller Supports: Height adjustable, size and load ratings for the application
   6. Bridge Assemblies:
      a. Suitable for multiple piping runs or equipment
      b. Size and load ratings for the application
   7. Post Base Assemblies:
      a. For use with vertical sections of channel support systems
      b. Size, channel support configuration, and load ratings for the application

D. Acceptable Manufacturers:
   1. Caddy/Pentair
   2. Cooper B-Line
   3. Mifab, Arlington
   4. Rooftop Blox
   5. Haydon
   6. MAPA Products
   7. Miro Industries

# PART 3 - EXECUTION

## 3.1 PREPARATORY WORK

A. Place inserts into construction form work expeditiously, so as not to delay the work of other trades.

3.2 INSTALLATION

A. Do not hang or support one (1) pipe from another or from ductwork.

B. Do not bend threaded rod.

C. Do not hang or support equipment from the bottom chord of joists.

D. Support all insulated horizontal piping conveying fluids below ambient temperature, by means of hangers or supports with insulation shields installed outside of the insulation.

E. Space hangers or supports for horizontal piping on maximum center distances as listed in the documents, and as follows.
   1. Cast Iron Soil Pipe:
      a. General:
         1) Where piping is suspended on centers in excess of 18 inches by means of non-rigid hangers, provide sway bracing to prevent horizontal pipe movement.
         2) Additionally, brace piping five (5) inches and larger to prevent horizontal movement and/or joint separation. Provide braces, blocks, rodding or other suitable method at each branch opening, or change of direction
      b. For Bell & Spigot Cast Iron Soil Pipe: Space hangers or support pipe at each joint or on maximum centers of five (5) feet. Place hangers or supports as close as possible to joints and when hangers or supports do not come within one (1) foot of a branch line fitting, install an additional hanger or support at the fitting.
      c. For Hubless Cast Iron Soil Pipe: Space hangers or support pipe at each joint or on maximum centers of five (5) feet. Place hanger or supports as close as possible to joints and when hangers or supports do not come within one (1) foot of a branch line fitting, install an additional hanger or support at the fitting.
   2. For Directional Changes: Install a hanger or support close to the point of change of direction of all pipe runs in either a horizontal or vertical plane.
   3. For Concentrated Loads: Install additional hangers or supports, spaced as required and directed, at locations where concentrated loads such as in-line pumps, valves, fittings or accessories occur, to support the concentrated loads.
   4. For Branch Piping Runs and Runouts Over 5 feet In Length: Install a minimum of one hanger, and additional hangers if required by the hanger spacing schedules.
   5. Parallel Piping Runs: Where several pipe lines run parallel in the same plane and in close proximity to each other, trapeze hangers may be used. Base hanger spacing for trapeze type hangers on the smallest size of pipe being supported. Design the entire hanger assembly based on a safety factor of five, for the ultimate strength of the material being used.

F. Size hanger rods in accordance with the following

| PIPE SIZE (Inches) | SINGLE ROD HANGER SIZE (Inches) | | DOUBLE ROD HANGER SIZE (Inches) | |
|---|---|---|---|---|
| | PIPE | TUBING | PIPE | TUBING |
| 1/2 to 2 | 3/8 | 1/4 | 3/8 | 1/4 |
| 2-1/2 and 3 | 1/2 | 3/8 | 3/8 | 1/4 |
| 4 and 5 | 5/8 | 1/2 | 1/2 | 3/8 |
| 6 | 3/4 | 1/2 | 5/8 | 1/2 |
| 8, 10 and 12 | 7/8 | 5/8 | 3/4 | 5/8 |

1. Secure hanger rods as follows: Install one (1) nut under clevis, angle or steel member; one (1) nut on top of clevis, angle or steel member; one (1) nut inside insert or on top of upper hanger attachment and one (1) nut and washer against insert or on lower side of upper hanger attachment. A total of four (4) nuts are required for each rod, two (2) at upper hanger attachment and two (2) at hanger.
2. Size hanger rods, for piping over 12 inches in size and multiple line supports, based on a safety factor of five for the ultimate strength of the materials being used.

G. Vertical Piping
1. Support vertical risers of piping systems, by means of heavy duty hangers installed close to base of pipe risers, and by riser clamps with extension arms at intermediate floors, with the distance between clamps not to exceed 25 feet, unless otherwise specified. Support pipe risers in vertical shafts equivalent to the aforementioned. Install riser clamps above floor slabs, with the extension arms resting on floor slabs. Provide adequate clearances for risers that are subject to appreciable expansion and contraction, caused by operating temperature ranges.
2. Support extension arms of riser clamps, secured to risers to be insulated for cold service, 4 inches above floor slabs, to allow room for insulating and vapor sealing around riser clamps.
3. Support cast iron risers, by means of heavy duty hangers installed close to the base of the pipe risers, and 1/4 inch thick malleable iron or steel riser clamps with extension arms at each floor level, with the distance between clamps not to exceed 25 feet. Support cast iron risers in vertical shafts equivalent to the aforementioned.
4. Support hubless cast iron risers, by means of heavy duty hangers installed close to the base of the pipe risers, and by malleable iron or steel riser clamps with the extension arms at each floor level, with the distance between clamps or intermediate supports not to exceed 12 feet. Support risers in vertical shafts equivalent to the aforementioned.

H. Floor Supports: Install adjustable yoke rests with base flanges, for the support of piping, unless otherwise indicated on the Drawings. Install supports in a manner, which will not be detrimental to the building structure.

I. Underground Cast Iron Pipe Supports: Firmly bed pipe laid underground, on solid ground along bottom of pipe. Install masonry piers for pipe laid in disturbed or excavated soil or where suitable bearing cannot be obtained.

3.3 UPPER HANGER ATTACHMENTS

A. General
1. Secure upper hanger attachments to overhead structural steel, steel bar joists, or other suitable structural members.
2. Do not attach hangers to steel decks that are not to receive concrete fill.
3. Do not attach hangers to precast concrete plank decks less than 2-3/4 inches thick.
4. Do not use flat bars or bent rods as upper hanger attachments.

B. Attachment to Steel Frame Construction: Provide intermediate structural steel members where required by pipe support spacing. Select steel members for use as intermediate supports based on a minimum safety factor of five.
1. Do not use drive-on beam clamps.
2. Do not support piping over 4 inches in size from steel bar joists. Secure upper hanger attachments to steel bar joists at panel points of joists.
3. Do not drill holes in main structural steel members.
4. Beam clamps, with tie rods as specified, may be used as upper hanger attachments for the support of piping, subject to clamp manufacturer's recommended limits.

C. Attachment to Concrete Filled Steel Decks
1. New Construction: Install metal deck ceiling bolts.
2. Existing Construction: Install welding studs (except at roof decks). Do not support a load in excess of 250 lbs from any single welded stud.
3. Do not attach hangers to decks less than 2-1/2 inches thick.

D. Attachment to Cast-In-Place Concrete: Secure to overhead construction by means of cast-in-place concrete inserts.

E. Attachment to Existing Cast-In-Place Concrete
1. For piping up to a maximum of 4 inches in size, secure hangers to overhead construction with self-drilling type expansion shields and machine bolts.
2. Secure hangers to wall or floor construction with single unit expansion shields or self-drilling type expansion shields and machine bolts.

F. Attachment to Cored Precast Concrete Decks: Toggle bolts may be installed in cells for the support of piping up to a maximum of 2-1/2 inches in size.

G. Attachment to Hollow Block or Hollow Tile Filled Concrete Decks
1. New Construction: Omit block or tile and pour solid concrete with cast-in-place inserts.
2. Existing Construction: Break out block or tile to access, and install machine bolt anchors at highest practical point on side of web.

H. Attachment to Waffle Type Concrete Decks
1. New Construction: Install cast-in-place inserts.
2. Existing Construction: Install machine bolt expansion anchors at highest practical point on side of web.

I. Attachment to Precast Concrete Tee Construction
   1. New Construction: Tee hanger inserts between adjacent flanges, except at roof deck without concrete fill.
   2. Existing Construction: Dual unit expansion shields in webs of tees. Install shields as high as possible in the webs.
      a. Exercise extreme care in the field drilling of holes to avoid damage to reinforcing.
      b. Do not use powder driven fasteners.

## 3.4 ANCHORS, RESTRAINTS, RIGID SUPPORTS, STAYS AND SWAY BRACES

A. Install pipe anchors, restraints and sway braces, at locations noted on the Drawings. Design anchors so as to permit piping to expand and contract freely in opposite directions, away from anchor points. Install anchors independent of all hangers and supports, and in a manner that will not affect the structural integrity of the building.

B. Cast Iron Soil Piping Systems
   1. Where piping is suspended on centers in excess of 18 inches by means of non-rigid hangers, provide sway braces, of design, number and location in accordance with the Cast Iron Soil Pipe Institute's Cast Iron Soil Pipe and Fittings Handbook to prevent horizontal pipe movement.
   2. Additionally, brace piping five (5) inches and larger to prevent horizontal movement and/or joint separation. Provide braces, blocks, rodding or other suitable method at each branch opening, or change of direction in accordance with the Cast Iron Soil Pipe Institute's Cast Iron Soil Pipe and Fittings Handbook to prevent horizontal pipe movement.

## 3.5 COMBINATION CLEVIS HANGER, PIPE INSULATION SHIELD AND VAPOR BARRIER JACKETED HIGH DENSITY INSULATING SADDLES

A. Install a combination clevis hanger, pipe insulation shield and vapor barrier jacketed high density insulating saddles, at all points of support for piping or tubing to be insulated for cold service. Furnish companion high density vapor barrier jacketed saddle pieces, of the same material, thickness and length, for installation over the top 180 degree surface of pipe or tubing, at each point of support where an insulated clevis hanger is utilized.

## 3.6 PIPE INSULATION SHIELDS

A. Unless otherwise specified, install a pipe insulation shield, at all points of support. Center shields on all hangers and supports outside of high density insulation insert, and install in such a manner so as not to cut, or puncture jacket.

## 3.7 ROOFTOP SUPPORT SYSTEM

A. Install in accordance with manufacturer's instructions and recommendations.

B. Provide complete and adequate support of all piping and equipment.

C. The use of wood blocks for supporting piping or equipment is not permitted.

D. Consult roofing manufacturer for roof membrane compression capacities. If necessary, a compatible sheet of roofing material (isolation pad) may be installed under rooftop support to disperse concentrated loads and add further membrane protection.

E. Use properly sized clamps to secure piping or equipment.

**END OF SECTION**

**SECTION 230548**

**VIBRATION AND EXPANSION CONTROL**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the Vibration Isolation and Expansion Control Devices indicated by the Contract Documents with supplementary items necessary for proper installation.

B. All mechanical equipment, piping and ductwork as noted on the equipment schedule or in the specification shall be mounted on or suspended from vibration isolators to reduce the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

C. All isolation materials shall be supplied by the same manufacturer.

D. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.

E. Equipment included in This Section
1. Vibration isolation for piping, ductwork and equipment
2. Equipment isolation bases
3. Flexible piping connections
4. Resilient Pipe Anchors and Guides

1.2 SUBMITTALS

A. The manufacturer of vibration isolation shall provide submittals for products as follows
1. Descriptive Data:
   a. Schedules of flexibly mounted equipment, referencing drawings by number.
   b. Catalog cuts or data sheets on vibration isolators.
2. Drawings:
   a. Submit details of equipment bases including dimensions, structural member sizes and support point locations.
   b. Submit details of isolation hangers for ceiling hung equipment, piping and ductwork.
   c. Submit details of mountings for floor supported equipment, piping and ductwork.
   d. All hanger, mounting or pad drawings shall indicate deflections and model numbers as well as any other requirements in the specifications.
   e. Spring diameters, rated loads and deflections, heights at rated load and closed height shall be provided for all springs shown in the submittals in tabular form.
   f. Complete flexible connector details.

3. Design Submittal:
   a. Piping Expansion Compensation shall be performance based. All piping that requires expansion compensation will require the design information to be provided by the manufacturer.
   b. Expansion compensation and restraint details shall be submitted to comply with performance requirements and design criteria for the project. This shall include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   c. Include design calculations for static and dynamic loading for all systems components and equipment. Provide a summary of assumptions and system requirements.
   d. Horizontal and Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes.

## PART 2 - PRODUCTS

### 2.1 BASE MOUNTED NEOPRENE MOUNTINGS

A. Minimum static deflection of 0.35”

B. All metal surfaces shall be neoprene covered and have friction pads both top and bottom. Bolt holes shall be provided on the bottom and a tapped hole and cap screw on top.

C. Steel rails shall be used above the mountings under equipment such as small vent sets to compensate for the overhang.

D. Acceptable Manufacturers
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control
   3. Mason Industries
   4. Vibro-Acoustics
   5. Vibration Eliminator Co., Inc.
   6. Vibration Mountings & Controls, Inc.
   7. Twin City Hose
   8. Patterson
   9. Acrefine

### 2.2 BASE MOUNTED SPRING ISOLATORS – FREE STANDING

A. Free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4” neoprene acoustical friction pad between the baseplate and the support.

B. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Installed and operating heights shall be equal.

C. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8.

Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

D. Acceptable Manufacturers
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control
   3. Mason Industries
   4. Vibro-Acoustics
   5. Vibration Eliminator Co., Inc.
   6. Vibration Mountings & Controls, Inc.
   7. Twin City Hose
   8. Patterson
   9. Acrefine

## 2.3 BASE MOUNTED MULTIPLE BELLOW AIR SPRINGS – FREE STANDING

A. Powder coated upper and lower steel sections connected by a replaceable, flexible Nylon reinforced Neoprene element to achieve a maximum natural frequency of 3 Hz.

B. Burst pressure must be a minimum of three (3) times the published maximum operating pressure. All air spring systems shall be equipped with three (3) leveling valves connected to the building control air or a supplementary air supply to maintain elevation plus or minus 1/8”(3mm).

C. An air filter and water separator shall be installed before the air distribution system to the leveling valves. Submittals shall include natural frequency, as well as load and damping tests, all as performed by an independent lab or acoustician.

D. Acceptable Manufacturers
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control
   3. Mason Industries
   4. Vibro-Acoustics
   5. Vibration Eliminator Co., Inc.
   6. Vibration Mountings & Controls, Inc.
   7. Twin City Hose
   8. Patterson
   9. Acrefine

## 2.4 BASE MOUNTED SPRING ISOLATORS - RESTRAINED

A. Equipment with large variations in the operating and installed weight, such as chillers, boilers, etc., and equipment exposed to the wind such as cooling towers, roof mounted fans and roof mounted air handling equipment shall be mounted on restrained spring mountings. Include neoprene acoustical pad within a rigid sided housing that includes vertical limit stops to prevent spring extension when weight is removed and temporary steel spacers between the upper and lower housings. Housings shall serve as blocking during erection.

B. When the equipment is at full operating weight, the springs shall be adjusted to assume the weight

and the spacers removed, without changing the installed and operating heights.

C. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical as well as horizontal modes. The hole through the bushing shall be a minimum of 0.75" larger in diameter than the restraining bolt. Horizontal clearance on the sides between the spring assembly and the housing shall be a minimum of 0.5" to avoid bumping and interfering with the spring action.

D. Vertical limit stops shall be out of contact during normal operation. Cooling tower mounts are to be located between the supporting steel and the roof or the grillage and dunnage as shown on the drawings when there is no provision for direct mounting.

E. Housings and springs shall be powder coated and hardware electro galvanized.

F. Acceptable Manufacturers
1. Amber/Booth Company, Inc.
2. Kinetics Noise Control
3. Mason Industries
4. Vibro-Acoustics
5. Vibration Eliminator Co., Inc.
6. Vibration Mountings & Controls, Inc.
7. Twin City Hose
8. Patterson
9. Acrefine

## 2.5 BASE MOUNTED MULTIPLE BELLOWS AIR SPRINGS - RESTRAINED

A. Equipment with large variations in the operating and installed weight, such as chillers, boilers, etc., and equipment exposed to the wind such as cooling towers, roof mounted fans and roof mounted air handling equipment shall be mounted on air springs, but within a rigid sided housing that includes vertical limit stops to prevent spring extension when weight is removed and temporary steel spacers between the upper and lower housings. Housings shall serve as blocking during erection.

B. When the equipment is at full operating weight, the air springs shall be pressurized to take the weight so the spacers can be removed without changing the installed and operating heights.

C. All restraining bolts shall be large rubber grommets to provide cushioning in the vertical as well as the horizontal modes. The hole through the bushing shall be a minimum of 0.75"(20mm) larger in diameter than the restraining bolt. Horizontal clearance between the air spring assembly and the housing shall be a minimum of 0.5"(12mm) to avoid bumping and interference with the air spring action.

D. Vertical limit stops shall be out of contact during normal operation. Mountings and air spring parts shall be powder coated. Hardware electro galvanized. Air spring systems shall be connected to the building control air or a supplementary air supply and equipped with three (3) leveling valves to maintain level within plus or minus 0.125". Cooling tower mounts are to be located between the supporting steel and the roof or the grillage and dunnage as shown on the drawings when there is no provision for direct mounting.

## 2.6 SPRING HANGERS

A. Spring and Neoprene Hanger
   1. Assembly shall consist of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring, seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box.
   2. In order to maintain stability, the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing and short circuiting the spring

B. Pre-compressed Spring and Neoprene Hanger
   1. Assembly shall be as described in 1, but they shall be pre-compressed and locked at the rated deflection by means of a resilient upstop to keep the piping or equipment at a fixed elevation during installation.
   2. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale.
   3. Springs are seated in a steel washer reinforced neoprene cup that has a neoprene bushing projecting through the bottom hole to prevent rod to hanger contact.
   4. Spring diameters and the lower hole sizes, shall be large enough to allow the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing.

C. Pre-Compressed Spring and Neoprene Hanger for Ductwork
   1. If ducts are suspended by flat strap iron, the hanger assembly shall be modified by the manufacturer with an eye on top of the box and on the bottom of the spring hanger rod to allow for bolting to the hanger straps.

D. Acceptable Manufacturers
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control
   3. Mason Industries
   4. Vibro-Acoustics
   5. Vibration Eliminator Co., Inc.
   6. Vibration Mountings & Controls, Inc.
   7. Twin City Hose
   8. Patterson
   9. Acrefine

## 2.7 STEEL BASES

A. Steel Beam Box Style Base
   1. Vibration isolation manufacturer shall furnish integral structural steel bases for equipment not supplied with manufacturer's base. Rectangular bases are preferred for all equipment.
   2. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.

3. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1".

B. Steel Beam Base RailsVibration isolation manufacturer shall provide steel members welded to height saving brackets to cradle equipment having legs or bases that do not require a complete supplementary base.Members shall have sufficient rigidity to prevent distortion of equipment.

C. Steel Beam Concrete Filled Base
1. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating concrete bases.
2. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6". The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity.
3. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured.
4. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base.
5. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable.

D. Acceptable Manufacturers
1. Amber/Booth Company, Inc.
2. Kinetics Noise Control
3. Mason Industries
4. Vibro-Acoustics
5. Vibration Eliminator Co., Inc.
6. Vibration Mountings & Controls, Inc
7. Twin City Hose
8. Patterson
9. Acrefine

## 2.8 VIBRATION ISOLATION ROOF CURB

A. Curb mounted rooftop equipment shall be mounted on vibration isolation bases that fit over the roof curb and under the isolated equipment. The extruded aluminum top member shall overlap the bottom to provide water runoff independent of the seal. Aluminum members shall house electro galvanized or powder coated springs selected for 0.75"(20mm) minimum deflection. Travel to solid shall be 1.5"(40mm) minimum. Spring diameters shall be no less than 0.8 of the spring height at rated load. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4"(6mm) so as not to interfere with the spring action except in high winds. Manufacturer's self adhering closed cell sponge gasketing must be used both above and below the base and a flexible EPDM duct like connection shall seal the outside perimeter. Foam or other sliding or shear seals are unacceptable in lieu of the EPDM duct-like closure. Submittals shall include spring deflections, spring diameters, compressed spring height and solid spring height as well as seal and wind resistance details. Curb mounted bases shall be Type CMAB as manufactured by Mason Industries, Inc.

B. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4"(6mm) thick. Steel springs shall be laterally stable and rest on 1/4"(6mm) thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curb's waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2"(50mm) of insulation. Curb shall be type RSC as manufactured by Mason Industries, Inc.

## 2.9 PIPE EXPANSION JOINTS

A. Pipe Expansion Joints (Rubber Type)
   1. Rubber expansion joints shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement. Substitutions must have certifiable equal or superior characteristics. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable.
   2. Sizes 1-1/2" through 14" shall have a ductile iron external ring between the two (2) spheres. Sizes 16" through 24" may be single sphere. Sizes 3/4" through 2" may have one sphere, bolted threaded flange assemblies and cable retention.
      a. Minimum ratings through 14" shall be 250psi at 170°F and 215psi at 250°F, 16" through 24" 180psi at 170°F and 150psi at 250°F. Higher published rated connectors may be used where required.
      b. Safety factors shall be a minimum of 3/1. All expansion joints must be factory tested to 150% of maximum pressure for 12 minutes before shipment.
      c. The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2" thick Neoprene washer bushings large enough to take the thrust at 1000psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them.
      d. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves.

B. Pipe Expansion Joints (Stainless Steel)
   1. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes may have male nipples.
   2. Minimum lengths shall be as follows:

| Flanged | | |
|---|---|---|
| 3" x 18" (75 x 300mm) | 6" x 24" (150 x 450mm) | 12" x 36" (300 x 600mm) |
| 4" x 18" (100 x 300mm) | 8" x 24" (200 x 450mm) | 14" x 36" (350 x 750mm) |

| | | |
|---|---|---|
| 5” x 24” (125 x 450mm) | 10” x 24” (250 x 450mm) | 16” x 36” (400 x 800mm) |

| Male Nipples | | |
|---|---|---|
| 1/2" x 12" (12 x 300mm) | 1-1/4" x 12" (32 x 300mm) | 2" x 12" (50 x 300mm) |
| 3/4" x 12" (19 x 300mm) | 1-1/2"x 12" (38 x 300mm) | 2-1/2" x 12" (64 x 450mm) |
| 1" x 12" (25 x 300mm) | | |

3. At equipment, hoses shall be installed on the equipment side of the shut-off valves horizontal and parallel to the equipment shafts wherever possible.

C. Miscellaneous Piping Supports
   1. Pipe Alignment Guide (Spider Type):
      a. Primary and intermediate guides shall be of the radial type employing a heavy wall guide cylinder with weld down or bolt down anchor base.
      b. A two section guide spider, having 1/8" maximum diametrical clearance with guide cylinder inside diameter, bolted or welded tight to the carrier pipe which slides through the guide cylinder I.D. Cylinder shall be of sufficient size to clear pipe insulation and long enough to prevent over travel of the spider.
   2. Pipe Alignment Guide (Slide Type):
      a. Primary and intermediate guides shall be of the sliding type. Two piece construction employing a sliding member to be welded to the carrier pipe and a weld down or bolt down anchor base.
      b. Sliding member shall be of sufficient height to clear pipe insulation and long enough to prevent over travel of the slide. Load bearing surfaces shall be Teflon to Teflon (T/T-standard), Teflon to Stainless (T/S), or Graphite to Graphite (G/G) as required for the application.
   3. Style RG – Riser Pipe Alignment Guide (Glide Type):
      a. Primary guides shall be of the vertical sliding type. Guides to be used in all building riser, piping systems in conjunction with the Metraflex HPL series compensators (specification #35).
      b. Glide series floor and ceiling pipe guides to be installed in pairs, at the floor and ceiling penetrations, and require no additional intermediate guides. Two piece construction employing a sliding member to be welded to the carrier pipe and a bolt down anchor base. Sliding member shall be of sufficient height to clear pipe insulation and long enough to prevent over travel of the slide. Stationary member shall consist of a steel mounting bracket, containing an isolating slide bearing to prevent the transmission of vibration and mechanically transmitted sound to the building structure.
      c. Riser pipe alignment guides shall be style “RG” as manufactured by The Metraflex Company®, Chicago, IL.
   4. Split Seals consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not in place prior to the construction of the

building member. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240°F, 10 lb. density fiberglass may be used in lieu of the sponge.

5. All-directional acoustical pipe anchors, consist of two (2) sizes of steel tubing separated by a minimum 1/2" thickness of 60 duro or softer neoprene. Vertical restraint shall be provided by similar material arranged to prevent up or down vertical travel. Allowable loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction.
6. Pipe guides shall consist of a telescopic arrangement of two (2) sizes of steel tubing separated by a minimum 1/2" thickness of 60 durometer or softer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Guides shall be capable of 1-5/8" motion, or to meet location requirements.
7. The first four (4) pipe hangers in the main lines near the mechanical equipment or as shown on plan shall be isolated. The first four (4) isolators from the isolated equipment shall have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first four (4) hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1-1/2" deflection for pipe sizes over 3" and up to and including 6", and 2-1/2" deflection thereafter.
9. Where piping connects to mechanical equipment install expansion joints or stainless hoses.
10. All vertical risers shall be supported by spring isolators designed to support the riser filled with water, if it is a water line. Assigned loads must be within the building design limits at the support points. Neutral central resilient anchors close to the center of the run shall direct movement up and down. The anchors shall be capable of holding an upward force equal to the water weight when the system is drained. If one (1) level cannot accommodate this force, anchors can be located on two (2) or three (3) adjacent floors. Resilient guides shall be spaced and sized properly depending on the pipe diameter. Submittals must include the initial load, initial deflection, change in deflection, final load and change in load at all spring and anchor support locations, as well as guide spacing. The initial spring deflection shall be a minimum of 0.75"(20mm) or four (4) times the thermal movement at the isolator location, whichever is greater. Calculations shall include pipe stress at end conditions and branch off locations and the manufacturer must include installation instructions. Submittal must be stamped and signed by a licensed professional engineer in the employ of the vibration vendor for at least five (5) years. Proper provision shall be made for seismic protection in seismic zones. The isolator manufacturer shall be the same firm supplying the mechanical contract. Support spring mountings shall be Specification B, anchors Specification R, telescoping guides Specifications.
11. All air ducts with a cross section of $2ft^2$ ($0.19m^2$) or larger shall be isolated from the building structure by specification H hangers or B floor supports with a minimum deflection of 0.75" (20mm). Isolators shall continue for 50' (15m) from the equipment. If air velocity exceeds 1000 fpm (5.3 mps), hangers or supports shall continue for an additional 50' (15m) or as shown on the drawings.

D. Acceptable Manufacturers
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control
   3. Mason Industries
   4. Vibro-Acoustics
   5. Vibration Eliminator Co., Inc.

6. Vibration Mountings & Controls, Inc.
7. Twin City Hose
8. Patterson
9. Acrefine

PART 3 - EXECUTION

3.8 GENERAL

A. All vibration isolators must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or duct work resulting in stresses or misalignment.

C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes but is not limited to slabs, beams, columns, studs and walls.

E. Coordinate work with other trades to avoid rigid contact with the building.

F. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.

G. Bring to the architects/engineers attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor's expense.

H. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractor's expense.

I. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide seals.

J. Locate isolation hangers as near to the overhead support structure as possible.

K. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust when thrust forces exceed 10% of the equipment weight.

L. Rooftop equipment isolators must be bolted to the equipment and structure. Mountings must be designed to resist 100m/h wind loads.

**END OF SECTION**

**SECTION 230553**

**MECHANICAL IDENTIFICATION**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Equipment Identification indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Items to be labeled
   1. Plumbing and Piping Valves
   2. Piping
   3. Equipment (Including but not limited to the following)
      a. Air Handling Units (AHU, RTU, ERU, Blower Coil, Makeup Air Units)
      b. Fans
      c. Terminal Devices (TAB, Heat Pumps, Fan Coil, Cabinet Heater, Unit Heater)
      d. Pumps
      e. Condensing Units
      f. Dedicated equipment control panels (sump pumps, sewage ejectors, radiant infloor heat zones)
   4. Variable Frequency Drives
   5. Thermostats
   6. Fire, Smoke and Fire / Smoke Dampers

1.2 REFERENCES

A. ANSI A13.1 - Scheme for Identification of Piping Systems.

1.3 SUBMITTALS

A. Product Data
   1. Manufacturer’s catalog sheets and specifications for mechanical identification materials.
   2. Installation instructions.
   3. Schedule indicating what type of materials will be used for various equipment, valves, piping, and devices.

PART 2 - PRODUCTS

2.1 EQUIPMENT TAGS

A. Aluminum Nameplates: Black enamel background with natural aluminum border and engraved letters furnished with two mounting holes and screws.

B. Plastic Tags: 1/16” thick, UV resistant phenolic plastic. Minimum 1-1/2" square or round laminated with engraved, 1/4" minimum black letters on light contrasting background.

C. Tags shall be black with white lettering.

D. Lettering: Lettering shall be supplier’s normal font, minimum 1” high

## 2.2 VALVE TAGS

A. Brass Tags: 1-1/2” Round 19 gauge brass tags with 1/4” minimum engraved letters.

B. Plastic Tags: 1/16” thick, UV resistant phenolic plastic. 1-1/2” round laminated with engraved, 1/4" minimum black letters on light contrasting background.

C. Tags shall be brass or white with solid black lettering.

D. Provide with brass ball chain or plastic zip connectors to attach tag to valve

## 2.3 PIPE MARKERS AND ACCESSORIES

A. Snap-on Marker: One (1) piece wrap around type constructed of pre-coiled acrylic plastic with clear polyester coating, integral flow arrows, legend printed in alternating directions, 3/4 inch adhesive strip on inside edge, and 360 degree visibility.

B. Strap-On Marker: Strip type constructed of pre-coiled acrylic plastic with clear polyester coating, integral flow arrows, legend printed in alternating directions, factory applied grommets, and pair of stainless steel spring fasteners.

C. Stick-On Marker: Pressure sensitive adhesive backed type constructed of vinyl with clear polyester coating, and integral flow arrows for applications where flow arrow banding tape is not being used.

D. Underground Marker: 6” wide, thickness depends on type. Detectable or non-detectable is acceptable. Provide detectable type for non-metallic piping such as plastic gas, water main, or underground PVC piping.

E. Pipe Marker Legend and Color Field Sizes:

| OUTSIDE DIAMETER OF PIPE OR INSULATION (Inches) | LETTER SIZE (Inches) | LENGTH OF COLOR FIELD (Inches) |
|---|---|---|
| 3/4 to 1-1/4 | 1/2 | 8 |
| 1-1/2 to 2 | 3/4 | 8 |
| 2-1/2 to 6 | 1-1/4 | 12 |
| 8 to 10 | 2-1/2 | 24 |

| OUTSIDE DIAMETER OF PIPE OR INSULATION (Inches) | LETTER SIZE (Inches) | LENGTH OF COLOR FIELD (Inches) |
|---|---|---|
| Over 10 | 3-1/2 | 32 |

F. Banding Tapes: Pressure sensitive adhesive backed type constructed of vinyl with clear polyester coating.
   1. Plain Tape: Unprinted type; color to match pipe marker background.
   2. Flow Arrow Tape: Printed type with integral flow arrows; color to match pipe marker background.

G. Pipe Size Labels: Pressure sensitive adhesive backed type constructed of vinyl with clear polyester coating, vertical reading pipe size in inches, and legend size matching adjacent pipe marker.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Complete testing, insulation and finish painting work prior to completing the Work of this Section.

B. Clean pipe surfaces with cleaning solvents prior to installing piping identification.

C. Remove dust from insulation surfaces with clean cloths prior to installing piping identification.

### 3.2 PIPING IDENTIFICATION

A. Install the Work of this Section in accordance with the manufacturer’s printed installation instructions, unless otherwise specified.

B. Stick-On Pipe Markers:
   1. Install minimum of two (2) markers at each specified location, 90 degrees apart on visible side of pipe.
   2. Encircle ends of pipe markers around pipe or insulation with banding tape with one inch lap. Use plain banding tape on markers with integral flow arrows, and flow arrow banding tape on markers without integral flow arrows.

C. Pipe Size Labels: Install labels adjacent to each pipe marker and upstream from flow arrow. Install a minimum of two (2) pipe size labels at each specified location, 90 degrees apart on visible side of pipe.

D. Underground Pipe Markers: Install 8-12” above buried piping. Install along entire length of pipe.

## 3.3 PIPING IDENTIFICATION SCHEDULE

A. Piping Identification Types

| Piping: | Field Color: | Lettering Color: |
|---|---|---|
| Domestic Water | Green | White |
| Sanitary, Vent, Condensate, Drain | Green | White |
| Refrigerant Piping | Yellow | Black |
| Natural Gas | Yellow | Black |
| Sprinkler-Fire | Red | White |
| Compressed Air | Blue | White |

B. Locate piping identification as follows:
   1. Locate piping identification at valve locations; at points where piping enters and leaves a partition, wall, floor or ceiling, and at intervals of 20 feet on straight runs.
   2. Where two (2) or more pipes run in parallel, place printed legend and other markers in same relative location.

## 3.4 EQUIPMENT IDENTIFICATION

A. Install engraved tags on equipment using metal rivets or stainless steel sheet metal screws with a pan head. For indoor equipment, industrial strength double-sided tape is acceptable if rivets or screws cannot be used. Install label on most visible side of equipment. Place identification along center line of equipment, if possible.

B. Label all mechanical equipment using the same callout as used on the drawings, by means of engraved tags.

C. Label all fire, fire/smoke, and smoke dampers with adhesive labels or permanent nameplates. Labels shall read “Fire Damper”, “Fire/Smoke Damper”, or “Smoke Damper” to match damper type.

D. Do not label equipment in exposed public spaces, e.g. cabinet unit heaters, diffusers, louvers, etc.

E. Label hidden equipment such as sump pumps on the control panel or disconnect if it does not make sense to label the equipment itself.

F. Label thermostats with the corresponding terminal air box or equipment served.

## 3.5 VALVE TAGS

A. Valve tags shall be engraved with the following information:
   1. Service Abbreviation
   2. Valve number

B. Service Abbreviation shall match piping nomenclature used on Drawings.

C. Attach tags to valves, not valve handles or wheels.

D. Trim excess from connecting strip or chain.

E. Valve Schedule
   1. Provide a valve schedule that lists all valves not installed for individual plumbing fixtures. Valve schedule shall list the following information in order: service, tag number, size, usage (shut-off, balancing, control, etc.), name and number or room location, normally open or closed, pressure rating, manufacturer, model number, and installation date.
   2. Provide three (3) laminated hard copies and one (1) electronic copy in .pdf format. Hard copies shall be clearly legible and a minimum of 11" x 17".
   3. Mount one (1) of the hard copies in a solid metal frame in a location designated by the Owner.

3.6 SPECIAL CONDITIONS

A. Additional labels shall be installed at the request of the Engineer/Owner.

**END OF SECTION**

**SECTION 230593**

**CLEANING AND TESTING**

PART 1 - GENERAL

1.1 SCOPE

A. Cleaning of systems to remove construction debris and prepare for testing and operation.

B. Perform testing on systems and equipment to confirm they can withstand normal operating and design conditions as outlined in various equipment sections.

C. Equipment Included in This Section
   1. Refrigerant piping
   2. Natural gas piping
   3. Domestic water piping
   4. Compressed air piping

1.2 REFERENCES

A. Balancing of Systems: Section 230594.

1.3 SUBMITTALS

A. Quality Control Submittals
   1. Submit Field Test Reports for all systems to be tested.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements
   1. Perform factory testing of factory fabricated equipment in complete accordance with the agencies having jurisdiction.
   2. Perform field testing of piping systems in complete accordance with the local utilities and other agencies having jurisdiction and as specified.

1.5 PROJECT CONDITIONS

A. Protection: During test Work, protect controls, gages and accessories which are not designed to withstand test pressures. Do not utilize permanently installed gauges for field testing of systems.

1.6 SEQUENCING AND SCHEDULING

A. Transmit written notification of proposed date and time of operational tests to the Architect / Engineer at least five (5) days in advance of such tests.

B. Perform cleaning and testing Work in the presence of the Owner's Representative Architect / Engineer.

C. Pressure test piping systems inside buildings, at the roughing-in stage of installation, before piping is enclosed by construction Work, and at other times as directed. Perform test operations in sections as required and directed, to progress the Work in a satisfactory manner and not delay the general construction of the building. Valve or cap-off sections of piping to be tested, utilizing valves required to be installed in the permanent piping systems or temporary valves or caps as required to perform the Work.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Test Equipment and Instruments: Type and kind as required for the particular system under test.

B. Test Media (air, gas, refrigerant, dry nitrogen, vacuum, water): As specified for the particular piping or system under test.

C. Cleaning Agent (chemical solution, steam, water): As specified for the particular piping, apparatus or system being cleaned.

D. Propylene Glycol: Permanent type anti-freeze solution as manufactured by Dow Chemical Co. or Union Carbide.

PART 3 - EXECUTION

A. Thoroughly clean pipe and tubing prior to installation. During installation, prevent foreign matter from entering systems. Prevent if possible and remove stoppages or obstructions from piping and systems.

B. Thoroughly clean compressed air, control air, refrigerant pipe and similar systems prior to pressure or vacuum testing.
   1. Refrigerant Piping
      a. Only use factory sealed refrigerant piping.
      b. Crimp and braze caps on ends of previously cleaned piping at the end of the day if piping was cut.
      c. When brazing, purge lines with dry nitrogen.

3.2 PRESSURE TESTING OF PIPING

A. Piping shall be tight under test and shall not show loss in pressure or visible leaks, during test operations or after the minimum duration of time as specified. Remove piping which is not tight under test; remake joints and repeat test until no leaks occur.

B. Water Systems
   1. Domestic water (potable cold, domestic hot and recirculation) inside buildings:
      a. Before fixtures, faucets, trim and accessories are connected, perform hydrostatic test at 125 psig minimum for four (4) hours.
      b. After fixtures, faucets, trim and accessories are connected, perform hydrostatic retest at 75 psig for four (4) hours.

C. Gas Piping: Before backfilling or concealment perform air test of duration and pressure as required by the local gas company. However, for gas piping designed for pressures of from 4 inches to 6 inches water column, air test at 15 inches Hg for one (1) hour, without drop in pressure. Test gas piping with air only. Check joints for leaks with soap suds.

D. Air Piping
   1. Compressed Air: Test with air at 150 psig for one (1) hour.
   2. Check joints for leaks with soap suds.

3.3 HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS - CLEANING AND OPERATIONAL TESTING

A. Circulating Heating Hot Water and Chilled Water Systems in Buildings
   1. Cleaning
      a. Flush systems and apparatus, upon completion of pressure test(s).
      b. Completely open valves and flush each system with clean water, prior to chemical cleaning.
      c. Repeatedly flush at short intervals until twice the system water capacity has been flushed through.
      d. Chemically clean systems immediately following flushing operations.
      e. Circulate a solution consisting of trisodium phosphate, in a proportion of one (1) pound of chemical to every 50 gallons of water in the system.
      f. Completely fill system with cleaning solution; vent as required, and place in operation, with automatic controls operating and valves fully open.
      g. Allow system to reach design operating temperature or an operating temperature designated by the Director’s Representative.
      h. Circulate the solution through the system for a minimum of four (4) consecutive hours; immediately drain system and flush with clean water until the pH at the farthest drain matches the clean water input.
      i. Provide temporary pipe and /or hose required to drain system.
      j. Keep strainers unplugged during cleaning operations. Remove and clean strainer screens prior to operational test.
      k. Refill system with clean water and correct pH to 7.
      l. Do not flush steam piping thru steam coils. Provide temporary steam supply and condensate piping to bypass steam coils.

m. Upon completion of flushing, remove temporary piping and reconnect steam coil.

2. Operational Test
   a. Run system in an automatic mode for a minimum of 120 consecutive hours.
   b. During this time, make final adjustments, including the setting of the balancing valves.

## 3.4 REFRIGERATION SYSTEMS – TESTING, DEHYDRATION AND CHARGING

A. Leak Test Procedure
   1. Refrigerant Piping Systems
      a. Pressurize with dry nitrogen to 50 psig and test for leaks using a bubble type solution.
      b. Release this partial test pressure and correct deficiencies.
      c. Charge system with a trace of refrigerant to 15 psig, then add dry nitrogen until system test pressures are reached and retest for leaks with an electronic leak detector.
      d. Release pressure, repair leaks and retest as necessary until no leaks occur.
      e. Recover refrigerant used for leak testing.
   2. System Test Pressures
      a. Charge system with dry nitrogen and trace of refrigerant (HFC 134A, HFC 407C, or HFC 410A) to 350 psig and retest for leaks with an electronic leak detector. The system must stay at 350 psig pressure for 24 hours to pass the system test pressure test.
      b. Release pressure, repair leaks and retest as necessary until no leaks occur.
      c. Recover refrigerant used for leak testing.

B. Dehydration
   1. Low and Ultra Low Temperature Refrigeration Systems (-30° F to 32° F):
      a. Following pressure tests dehydrate each system with a vacuum pump.
      b. Draw and hold an initial vacuum of 800 microns. Break this vacuum by pressurizing with dry nitrogen to 10 psig, and change oil in vacuum pump.
      c. Draw and hold a second vacuum of 500 microns. Break this vacuum by pressurizing with dry nitrogen to 10 psig, and change oil in vacuum pump.
      d. Draw and hold a third vacuum of 250 microns for eight (8) to twelve (12) hours with an allowable maximum rise of 50 microns. Break this third vacuum by adding liquid refrigerant specified for the equipment to the high side of the system (liquid line).
      e. Verify vacuum obtained with an electronic vacuum gauge.
   2. Medium Temperature Refrigeration Systems (33° F to 55° F), and Air Conditioning Systems:
      a. Following pressure tests dehydrate each system with a vacuum pump.
      b. Draw and hold an initial vacuum of 500 microns. Break this vacuum by pressurizing with dry nitrogen to 10 psig, and change oil in vacuum pump.
      c. Draw and hold a second vacuum of 500 microns. Break this vacuum by pressurizing with dry nitrogen to 10 psig, and change oil in vacuum pump.
      d. Verify vacuum obtained with an electronic vacuum gauge.

C. Refrigerant Charging: Follow equipment manufacturer's printed charging directions unless otherwise specified.
   1. Introduce refrigerant of type and quantity required through a filter/drier installed in the temporary charging line.
      a. Purge small amount of liquid out of the system side of the charging hose.
      b. Prevent moisture and other contaminants from entering the system.
   2. Charge liquid refrigerant through a charging valve provided in the high pressure side of the system.
      a. Small amounts of gaseous refrigerant may be charged through the compressor suction service valve port.
   3. No bubbles shall appear at the moisture-liquid indicator when the system is fully charged and operational. Do not overcharge.
   4. Record the weight in pounds of refrigerant charged into each system and submit this record to the Director's Representative.

D. Compressor Oil Charge: Pump oil into the compressor after the last vacuum has been preformed. Follow all Manufactures Recommended for oil type and amount to be installed.

E. Adjustments and Operational Testing
   1. Adjustments: Place the system in operation with automatic controls functioning. Adjust controls and apparatus for proper operation. Test thermometers and gauges for accuracy over the entire range. Remove and replace items found defective.
      a. Check belts, fan blades, fittings, TXV bulbs, and electrical connections for tightness before start up.
      b. Check TXV bulb for proper location should be between 8 and 10 o'clock or 2 & 4 o'clock.
      c. Seal off all holes in the condition space as specified.
      d. Provide a point to point control check of the system to ensure that the specified inputs and outputs are receiving the signal from the proper sensors or controlling the proper device.
      e. Set pressure controls and safety controls.
      f. Close or de-energize all solenoids, and start up the system.
      g. Check that all controls and safety switches are operating properly.
      h. Adjust TXV for proper super heat back to the compressors.
      i. Clean TXV strainers as many times as required.
      j. After one (1) week of run time, change the liquid cores if they are the replaceable type.
      k. After one (1) month of run time, replace the liquid cores and compressor suction socks. Replace the liquid cores as required. Clean the TXV's as required.

## 3.5 DISINFECTION OF POTABLE WATER SYSTEMS

A. Disinfect potable water pipe and equipment installed in the Work of this Contract.
   1. Completely fill the piping, including water storage equipment if installed, with a water solution containing 50 mg/L available chlorine, and allow stand for twenty-four (24) hours.
   2. Operate all valves during this period to assure their proper disinfection.

3. After the retention period, discharge the solution to an approved waste and flush the system thoroughly with water until substantially all traces of chlorine are removed.
4. Drain and flush water storage equipment if installed.

B. Connect plumbing fixtures and equipment and place the system into service. Prevent recontamination of the piping during this phase of the Work.

**END OF SECTION**

**SECTION 230594**

**TESTING ADJUSTING AND BALANCING**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required for complete Testing, Adjusting and Balancing of the systems as indicated by the Contract Documents with supplementary items necessary for proper system operation.

B. Equipment included in This Section
1. Air Handling Equipment
2. Air handling units
3. Single duct terminal air boxes
4. Exhaust fans
5. Air inlets and outlets
6. Plumbing Equipment
7. Hot water circulation pump
8. Hot water circulation branch balancing valves
9. Domestic water booster pump

1.2 SUBMITTALS

A. Certified TAB reports

1.3 QUALITY ASSURANCES

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB, or TABB.
1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB, or TABB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB, or TABB as a TAB technician.

1.4 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.5 PROJECT CONDITION

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations

1.6 COORDINATION

A. Notice: Provide seven (7) days advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent
   2. Air Outlets and Inlets: Plus or minus 10 percent

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, engage one (1) of the following
   1. Precision Facility Solutions
   2. System Management and Balance
   3. System Works

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 systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section "Metal Ductwork" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design". Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

## 3.3 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:
   1. Permanent electrical-power wiring is complete.
   2. Automatic temperature-control systems are operational.
   3. Equipment and duct access doors are securely closed.
   4. Balance, smoke, and fire dampers are open.
   5. Isolating and balancing valves are open and control valves are operational.
   6. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   7. Windows and doors can be closed so indicated conditions for system operations can be met.

## 3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in this specification and one of the following:
   1. AABC's "National Standards for Total System Balance"
   2. ASHRAE 111
   3. NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"
   4. SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing"

B. Comply with requirements of the adopted version of ASHRAE 62.1, Section on balancing.

C. 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 Division 23 Section "HVAC Insulation”.

D. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

E. Take and report testing and balancing measurements in inch-pound (IP).

## 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. Crosscheck the summation of required outlet volumes with required fan volumes.

B. For variable-air-volume systems, develop a plan to simulate diversity.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ductwork."

## 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.
   2. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow
   3. Measure fan static pressures as follows to determine actual static pressure:
   4. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
   5. Measure static pressure a few feet downstream of a fan or in a location that will avoid turbulent or unrepeatable performance.
   6. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
   7. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
   8. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   9. Report the cleanliness status of filters and the time static pressures are measured.
   10. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
   11. Balancer can adjust fan speeds 15% higher or lower than speed indicated in the approved shop drawing to meet the required capacity. If a fan needs to operate outside these parameters to meet the capacity requirements, balancer to contact the Engineer for approval. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance

12. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to indicated airflows within specified tolerances.
   1. Measure airflow of sub-main and branch ducts.
   2. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
   3. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
   4. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.
   1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
   1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   2. Adjust patterns of adjustable outlets for proper distribution without drafts.

## 3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
   1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
   2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
6. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
7. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
8. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
9. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
10. Record final fan-performance data.

## 3.8 PROCEDURES FOR MOTORS

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

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

## 3.9 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor 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
   4. Air pressure drop

3.10 FINAL REPORT

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

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Pump curves
   2. Fan curves
   3. Manufacturers' test data
   4. Field test reports prepared by system and equipment installers
   5. Other information relative to equipment performance; do not include Shop Drawings and product data

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

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:
   1. Quantities of outdoor, supply, return, and exhaust airflows.
   2. Duct, outlet, and inlet sizes.
   3. Terminal units.
   4. Balancing stations.

5. Position of balancing devices.

## 3.11 INSPECTIONS

A. Initial Inspection
   1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
   2. Check the following for each system:
   3. Measure airflow of at least ten (10) percent of air outlets.
   4. Measure water flow of at least five (5) percent of terminals.
   5. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   6. Verify that balancing devices are marked with final balance position.
   7. Note deviations from the Contract Documents in the final report.

B. Final Inspection
   1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Commissioning Authority.
   2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.
   3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal eight (8)-hour business day.
   4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
   5. If the number of "FAILED" measurements is greater than ten (10) percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
   1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
   2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.12 ADDITIONAL TESTS

A. Within ninety (90) days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

**END OF SECTION**

**SECTION 230713**

**DUCTWORK INSULATION**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Ductwork Insulation indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
   1. Insulation
   2. Fasteners
   3. Jacketing
   4. Sealants

1.2 REFERENCES

A. Ductwork schedules located on Drawings.

B. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed in the following references:
   1. NFPA 90
   2. ASTM

C. Abbreviations
   1. K: Thermal Conductivity, in Btu per inch thickness per hour per square foot.
   2. PVC: Polyvinylchloride

1.3 SUBMITTALS

A. Product Data
   1. Manufacturer's catalog sheets and specifications for insulation materials and jacket materials.
   2. Materials Schedule: Itemize insulation materials and thicknesses for each specified application in Insulation Material Schedules in Part 3 of this Section. Where optional materials are specified, indicate option selected. Schedule should be similar to Ductwork schedule on Drawings.

1.4 QUALITY ASSURANCE

A. Qualifications: The persons installing the Work of this Section and their Supervisor shall be personally experienced in mechanical insulation work and shall have been regularly employed by a company installing mechanical insulation for a minimum of five (5) years.

B. Regulatory Requirements
   1. Insulation installed inside buildings, including duct lining materials, laminated jackets, mastics, sealants and adhesives shall have a Fire Spread/Smoke Developed Rating of 25/50 or less based on ASTM E 84.

PART 2 - PRODUCTS

2.1 ADHESIVES

A. 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).

B. Calcium Silicate Adhesive: fibrous, sodium-silicate-based adhesive with a service temperature range of 50° F - 800° F (10° C - 427° C).

C. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of -75° F to +300° F (-59° C to +149° C).

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, class 2, Grade A.

F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.2 MASTICS

A. For indoor applications, use mastics that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

2.3 LAGGING ADHESIVES

A. For indoor applications, use adhesive that has a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

## 2.4 JACKETS

A. PVC Jackets
1. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness: 0.030".
2. Adhesive: As recommended by jacket material manufacturer.
3. 3. Color: Color-code jackets based on system. Color as selected by Architect.

B. Stainless Steel Jackets:
1. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
2. Type 304 or Type 316 sheet and roll stock ready for shop or field sizing. Material thickness: 0.030".
3. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and 2.5mil- thick polysurlyn.

C. Aluminum Jackets:
1. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
2. Moisture Barrier for Outdoor Applications: 3-mil thick, heat-bonded polyethylene.

## 2.5 BANDING

A. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316 as required to match jacketing material; 0.015 inch thick, 3/4 inch wide with wing seals.

B. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seals.

## 2.6 SEALANTS

A. 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).

## 2.7 INSULATION

A. Ductwork Insulation Types
1. Type A: Flexible fiberglass duct wrap. Minimum density 0.75 #/ft$^3$, K of 0.30 at 75° F; ASTM C 553, Type II.
2. Type B: Semi-rigid fiberglass board wrap. Minimum density 3.0 #/ft$^3$, K of 0.23 at 75° F; ASTM C612, Type IA.

3. Type C: Flexible fiberglass duct liner. Minimum density 3.0 #/ft$^3$, K of 0.24 at 75° F; ASTM C 1071. Liner between insulation and airstream side of double-wall ductwork shall have a Fire Spread/Smoke Developed Rating of 25/50 or less based on ASTM E 84.
4. Type D: Preformed rigid fiberglass duct liner. Minimum density 3.0 #/ft$^3$, K of 0.23 at 75°F; ASTM C 1071. Liner shall have a Fire Spread/Smoke Developed Rating of 25/50 or less based on ASTM E 84
5. Type E: Flexible mineral fiber duct wrap (Suitable for Temperatures Up to 1800° F). Minimum density 6 #/ft$^3$; ASTM E 2336, NFPA 96-2011, UL 1978 (Rev. 6-02). Two (2)-hour fire separation rating with zero clearance to combustibles. Thickness shall be as specified or as required by AHJ to meet fire separation requirements.
6. Type F: Flexible fiberglass duct liner for spiral ductwork. Minimum density 3.0 #/ft$^3$, K of 0.23 at 75° F; Liner shall have a Fire Spread/Smoke Developed Rating of 25/50 or less based on ASTM E 84.

B. Fire resistant, anti-erosion, and anti-microbial coating on lining interior to duct; NFPA 90-A and 90-B.

C. All insulation densities listed are minimum densities. Contractor shall be responsible for verifying the required insulation thickness & density to meet the minimum installed insulation R-values as listed in the ductwork schedules on the drawings.

## PART 3 - EXECUTION

### 3.1 DUCT INSULATION SCHEDULE

A. Refer to Ductwork Application Schedule on Drawings for insulation requirements.

### 3.2 PREPARATION

A. Perform the following before starting insulation work.
1. Install hangers, supports and appurtenances in their permanent locations.
2. Complete testing of piping, ductwork, and equipment.
3. Clean and dry surfaces to be insulated.

### 3.3 INSTALLATION, GENERAL

A. Install the work of this section in accordance with the manufacturer’s printed installation instructions unless otherwise specified.

### 3.4 INSTALLATION AT HANGERS AND SUPPORTS

A. Reset and realign hangers and supports if they are displaced while installing insulation.

B. Insulation inserts for use with fibrous glass insulation:
   1. Ductwork: Install 6 #/ft$^3$ density jacketed fibrous glass board, same thickness as adjoining insulation, sized for full bearing on supporting trapeze member, and as required to enable abutting to adjoining insulation and overlapping of jacketing.

## 3.5 INSTALLATION OF DUCTWORK INSULATION

A. Exterior to Ductwork
   1. Cut insulation to stretch-out dimensions as recommended by insulation manufacturer.
   2. Remove two (2) inch wide strip of insulation material from the jacketing on the longitudinal and circumferential joint edges to form an overlapping staple/tape flap.
   3. Install insulation with jacketing outside so staple/tape flap overlaps insulation and jacketing on other end.
   4. Butt ends of insulation tightly together.
      a. Rectangular and Square Ductwork: Do not compress insulation at duct corners.
   5. Staple longitudinal and circumferential joints with outward clinching staples minimum six (6) inches on center, and seal with pressure sensitive sealing tape.
   6. Cut off protruding ends of fasteners flush with insulation surface and seal with pressure sensitive sealing tape.
   7. Install duct insulation fasteners on bottom side of horizontal duct runs, when bottom dimension of the duct is in excess of 24 inches in width.
   8. Install duct insulation fasteners on sides of duct risers having a dimension over 24 inches in size.
   9. Seal tears, punctures, and penetrations of insulation jacketing with sealing tape.

B. Interior to Ductwork
   1. Insulate ducts prior to erection in place when ducts are required to be installed proximate to walls, ceilings, equipment or other ductwork, which will not permit adequate space for installation of insulation after ducts are installed.
   2. Line interior surfaces of ducts with thermal and acoustic board insulation, when the specified application of exterior insulation is impractical.
      a. Written permission from the Engineer must be received, prior to the substitution of lined ducts for exterior insulated ducts.
      b. Maintain interior cross-sectional areas of ducts, as noted on drawings.

## 3.6 INSTALLATION OF JACKETING MATERIAL

A. PVC Jackets:
   1. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
   2. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

B. Metal Jackets:
   1. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

## 3.7 FIELD QUALITY CONTROL

A. Field Samples: The Director's Representative, may at his discretion, take field samples of installed insulation for the purpose of checking materials and application. Reinsulate sample cut areas.

## 3.8 DUCTWORK SERVICE INSULATION SCHEDULE

A. Insulate all ductwork except where otherwise specified. See Ductwork schedule on Drawings.

B. Notes
   1. Equipment: Insulate air handling equipment, not furnished with factory applied insulated jacket or internal insulation, with minimum 1-1/2 inch thick fibrous glass board with an ASTM C 1136 Type I jacket, installed and finished as specified for exposed ductwork in finished spaces.

**END OF SECTION**

**SECTION 230719**

**PIPING INSULATION**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the Piping Insulation indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Pipe Hangers and Supports: Section 230529.

B. Abbreviations
1. K: Thermal Conductivity, i.e., maximum Btu per inch thickness per hour per square foot.
2. pcf: Pounds per cubic foot.
3. PVC: Polyvinylchloride.

1.3 SUBMITTALS

A. Product Data: Manufacturer's catalog sheets and specifications for the following:
1. Insulation Materials.
2. Jacket Materials.
3. Sealant and Adhesive Materials.

1.4 QUALITY ASSURANCE

A. Qualifications: The person(s) directly supervising the installation of this work in the field shall be personally experienced in mechanical insulation work and shall have been regularly employed by a company installing mechanical insulation for a minimum of five (5) years.

B. Regulatory Requirements
1. Insulation installed inside buildings, including laminated jackets, mastics, sealants and adhesives shall have a Fire Spread/Smoke Developed Rating of 25/50 or less based on ASTM E 84.
2. Insulation shall meet minimum requirements ASHRAE 90.1-2007.

PART 2 - PRODUCTS

2.1 PIPING INSULATION

A. Fibrous Glass (Mineral Fiber) Insulation: Composed principally of fibers manufactured from rock, slag, or glass, with or without binders, and asbestos free.
   1. Preformed Pipe Insulation: Minimum density 3 pcf; ASTM C 547
      a. Class 1 (Suitable for Temperatures Up to 450° F): K of 0.26 at 75° F.
   2. Premolded Fitting Insulation: Minimum density 4.0 pcf, K of 0.26 at 75° F; ASTM C 547, Class 1.
   3. Insulation Inserts for PVC Fitting Jackets: Minimum density 1.5 pcf, K of 0.28 at 75° F; ASTM C 553, Type III. Suitable for temperatures up to 450° F.

B. Flexible Elastomeric Foam Insulation
   1. Pipe Insulation: ASTM C 534, Type I.
   2. Polyethylene and polyolefin insulation is not acceptable.

C. High Density Jacketed Insulation Inserts for Hangers and Supports
   1. For Use with Fibrous Glass Insulation:
      a. Cold Service Piping:
         1) Polyurethane Foam: Minimum density 4 pcf, K of 0.13 at 75° F, minimum compressive strength of 125 psi.
      b. Hot Service Piping:
         1) Calcium Silicate: Minimum density 15 pcf, K of 0.50 at 300° F; ASTM C 533.
         2) Perlite: Minimum density 12 pcf, K of 0.60 at 300° F; ASTM C 610.
   2. For Use with Flexible Elastomeric Foam Insulation: Hardwood dowels and blocks, length or thickness equal to insulation thickness, other dimensions as specified or required.

D. Cements
   1. Fibrous Glass Thermal Insulating Cement: Asbestos free; ASTM C 195.
   2. Fibrous Glass Hydraulic Setting Thermal Insulating and Finishing Cement: ASTM C 449/C 449M.

## 2.2 INSULATION JACKETS

A. Laminated Vapor Barrier Jackets for Piping: Factory applied by insulation manufacturer, conforming to ASTM C 1136, Type I.
   1. Type I: Reinforced white kraft and aluminum foil laminate with kraft facing out.
      a. Pipe Jackets: Furnished with integral 1-1/2” self sealing longitudinal lap, and separate 3” wide adhesive backed butt strips.
   2. Laminated vapor barrier jackets are not required for flexible elastomeric foam insulation.

B. Canvas Jackets: Cotton duck, fire retardant, NFPA 701 compliant, 4 or 6 oz. per square yard as specified.

C. PVC Jackets and Premolded Fitting Covers
   1. Constructed of high impact, UV resistant PVC. 0.020” thickness.
      a. ASTM D 1784, Class 14253-C.
      b. Working Temperature: 0-150° F.

D. Metal Jacketing
   1. Aluminum: ASTM B 209, Alloys 1100, 3003, 3105 or 5005, Temper H14, 0.016 inch thick.
      a. Factory Pre-formed Sectional Pipe Jacketing:
         1) Smooth outer finish with integral bonded laminated polyethylene film, kraft paper moisture barrier underside.
         2) Pittsburgh or modified Pittsburgh longitudinal lock seams.
         3) 2 inch overlapping circumferential joints with integral locking clips, or butt joints sealed with 2 inch wide mastic backed aluminum snap bands.
      b. Fastening Devices:
         1) Strapping: Type 18-8 stainless steel, 0.020” thick, 1/2" and 3/4" wide as specified.
         2) Wing Seals: Type 18-8 stainless steel, 0.032” thick.
   2. Circumferentially Corrugated Aluminum Jacketing: Childer’s Corrolon, or Prior Approved Equal.
      a. Construction: 3/16” circumferentially corrugated embossed aluminum, ASTM B 209, Types 1100, 3003, 3105, or 505, H-14 temper, 0.016” thick.
      b. Moisture Barrier: Integrally bonded to jacket over entire surface in contact with insulation.
      c. Fastening Devices:
         1) Strapping: 0.020” thick by 1/2" wide, Type 3003, 3105, 5005, H-14 temper.
         2) Wing Seals: 0.032” thick Type 5005, H-14 temper aluminum.

E. Self-Adhesive Outdoor Jackets:
   1. Self-Adhesive Outdoor Jacket: 15-mil thick, laminated vapor barrier and waterproofing membrane for installation over insulation located above ground and outdoors; consisting of a multi-layered laminate coating with acrylic adhesive covered with flat silver aluminum-foil facing.

F. Insulated Safety Wrap: Handi Lav-Guard by Truebro Inc., or Prior Approved Equal.
   1. Construction: 1/8” thick chemical resistant vinyl with internal ribs.
   2. Fasteners: Nylon tie laces or reuseable clips.
   3. Kit includes covering for 8” tailpiece, P trap, 8” waste arm, hot and cold lines and valves, and required fasteners.

G. Removable Insulation Covers: Advance Thermal Corp., or Prior Approved Equal.
   1. Construction: Teflon or silicon coated canvas blanket. Insulation shall match insulation thickness or be as thick as possible.
   2. Fasteners: A minimum of Velcro, double-loop d-rings, and laces.
   3. Use materials that are rated for an application’s specific temperature requirements, e.g. use high temperature (800° F) rated products for generator exhaust flues.

## 2.3 ADHESIVES, MASTICS, AND SEALERS

A. Adhesives
   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. Calcium silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 - 800° F (10 - 427° C).
3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive with a service temperature range of -75°F to +300°F (-59°C to +149°C)
4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
5. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
6. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
7. PVC Jacket Adhesive: Compatible with PVC jacket.

B. Mastics
1. For indoor applications, use mastics that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D(EPA Method 24).
2. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

C. Lagging Adhesives
1. For indoor applications, use adhesive that has a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D(EPA Method 24).
2. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

D. Sealants
1. 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. Vapor Seal Adhesive (Fibrous Glass Insulation): Childers' CP-82, Epolux's Cadoprene 400, Foster's 85-75 or 85-20.
3. Vapor Barrier Mastic/Joint Sealer (Fibrous Glass Insulation): Childers' CP-30, Epolux's Cadalar 670, Foster's 95-44 or 30-35.
4. Adhesive (Flexible Elastomeric Foam): Armstrong's 520, Childers' CP-80, Epolux's Cadoprene 488, Foster's 82-40.
5. Sealant (Metal Pipe Jacket): One-part silicone sealant for high temperatures; Dow Corning's Silastic 736 RTV or General Electric's RTV 106.

## 2.4 MISCELLANEOUS MATERIALS

A. Pressure Sensitive Tape for Sealing Laminated Jackets:
1. Acceptable Manufacturers:
   a. Alpha Associates
   b. Childers
   c. Ideal Tape
   d. Morgan Adhesive
2. Type: Same construction as jacket.

B. Wire, Bands, and Wire Mesh:
1. Binding and Lacing Wire: Nickel copper alloy or copper clad steel, gauge as specified.

2. Bands: Galvanized steel, 1/2" wide x 0.015” thick, with 0.032” thick galvanized wing seals.
3. Wire Mesh: Woven 20-gauge steel wire with 1” hexagonal openings, galvanized after weaving.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Perform the following before starting insulation Work:
   1. Install hangers, supports and appurtenances in their permanent locations.
   2. Complete testing of piping.
   3. Clean and dry surfaces to be insulated.

### 3.2 INSTALLATION, GENERAL

A. Install the Work of this Section in accordance with the manufacturer’s printed installation instructions unless otherwise specified.

B. Provide continuous piping insulation and jacketing when passing thru interior wall, floor, and ceiling construction.
   1. At Through Penetration Firestops: Coordinate insulation densities with the requirements of approved firestop system being installed. See Section 078400.
      a. Insulation densities required by approved firestop system may vary with the densities specified in this Section. When this occurs use the higher density insulation.

C. Do not intermix different insulation materials on individual runs of piping.

### 3.3 INSTALLATION AT HANGERS AND SUPPORTS

A. Reset and realign hangers and supports if they are displaced while installing insulation.

B. Install high density jacketed insulation inserts at hangers and supports for insulated piping.

C. Insulation Inserts For Use with Fibrous Glass Insulation
   1. Where clevis hangers are used, install insulation shields and high density jacketed insulation inserts between shield and pipe.
      a. Where insulation is subject to compression at points over 180° apart, e.g. riser clamps, U-bolts, trapezes, etc.; fully encircle pipe with two (2) protection shields and two (2) high density jacketed fibrous glass insulation inserts within supporting members.

D. Insulation Inserts For Use with Flexible Elastomeric Foam Insulation:

1. Where clevis hangers are used, install insulation shields with hardwood filler pieces, same thickness as adjoining insulation, inserted in undersized die cut or slotted holes in insulation at support points.
2. Contour hardwood blocks to match the curvature of pipe, and shield.
3. Coat dowels and blocks with insulation adhesive, and insert while still wet.
4. Vapor seal outer surfaces of dowels and blocks with adhesive after insertion.
5. Install filler pieces as follows:

| PIPE/TUBING SIZE | FILLER PIECES | POSITION |
|---|---|---|
| Thru 1-1/2” | 2 dowel plugs | 6 o’clock; in tandem |
| 2” thru 4” | 1 block, 2 dowel plugs | 6 o’clock, and<br>4 & 8 o’clock respectively |
| 6” thru 8” | 2 blocks, 4 dowel plugs | 6 o’clock; in tandem and<br>4 & 8 o’clock; in tandem |

## 3.4 INSTALLATION OF FIBROUS GLASS COLD SERVICE INSULATION

A. Install insulation materials with a field or factory applied ASTM C 1136 Type I laminated vapor barrier jacket, unless otherwise specified.

B. Piping
   1. Butt insulation joints together, continuously seal minimum 1-1/2” wide self-sealing longitudinal jacket laps and 3” wide butt adhesive backed strips.
      a. Substitution: 3” wide pressure sensitive sealing tape, of same material as jacket, may be used in lieu of butt strips.
   2. Bed insulation in a 2” wide band of vapor barrier mastic, and vapor seal exposed ends of insulation with vapor barrier mastic at each butt joint between pipe insulation and equipment, fittings or flanges at the following intervals:
      a. Horizontal Pipe Runs: 21 ft.
      b. Vertical Pipe Runs: 9 ft.

C. Fittings, Valves, Flanges and Irregular Surfaces
   1. Piping Systems (less than 40° F)
      a. Insulate with mitre cut or pre-molded fitting insulation of same material and thickness as pipe insulation.
      b. Secure insulation in place with 16-gauge wire, with ends twisted and turned down into insulation.
      c. Butt insulation against pipe insulation and bond with joint sealer.
      d. Insulate valves up to and including bonnets, without interfering with packing nuts.
      e. Insulate pump impeller casings on pump systems operating below 45° F.
      f. Apply leveling coat of insulating cement to smooth out insulation and cover wiring.

g. When insulating cement has dried, seal fitting, valve and flange insulation, by imbedding a layer of reinforcing membrane between two (2) flood coats of vapor barrier mastic, each 1/8" thick wet.
h. Lap reinforcing membrane or canvas on itself and adjoining pipe insulation at least 2 inches.
i. Trowel, brush or rubber glove outside coat over entire insulated surface.

2. Piping Systems (40 - 60° F)
   a. Valves, fittings and flanges shall be insulated with pre-molded PVC fitting jackets, with fibrous glass insulation inserts.
      1) Additional insulation inserts are required for services with operating temperatures under 45° F or where insulation thickness exceeds 1-1/2". The surface temperature of PVC fitting jacket must not go below 45° F.

## 3.5 INSTALLATION OF FIBROUS GLASS HOT SERVICE INSULATION

A. Install insulation materials with field or factory applied ASTM C 1136 Type I laminated vapor barrier jacket unless otherwise specified.

B. Piping
   1. Butt insulation joints together, continuously seal minimum 1-1/2" wide self-sealing longitudinal jacket laps and 3" wide adhesive backed butt strips.
      a. Substitution: 3" wide pressure sensitive sealing tape, of same material as the jacket, may be used in lieu of butt strips.
   2. Fill voids in insulation at hanger with insulating cement.
   3. Exceptions:
      a. Piping in Accessible Shafts, Attic Spaces, Crawl Spaces, Unfinished Spaces and Concealed Piping: Butt insulation joints together and secure minimum 1-1/2" wide longitudinal jacket laps and 3" wide butt strips of same material as jacket, with outward clinching staples on maximum 4" centers. Fill voids in insulation at hangers with insulating cement.
      b. Piping in Tunnels: Butt insulation joints together and secure minimum 1-1/2" wide longitudinal jacket laps and 3" wide butt strips, of same material as jacket, with outward clinching staples on maximum 4" centers and 16 gauge wires a minimum of four (4) loops per section. Fill voids in insulation with insulating cement.

C. Fittings, Valves, Flanges and Irregular Surfaces
   1. Insulate with mitre cut or pre-molded fitting insulation of same material and thickness as insulation.
   2. Secure in place with 16-gauge wire, with ends twisted and turned down into insulation.
   3. Butt fitting, valve and flange insulation against pipe insulation, and fill voids with insulating cement.
   4. Insulate valves up to and including bonnets, without interfering with packing nuts.
   5. Apply leveling coat of insulating cement to smooth out insulation and cover wiring.
   6. After insulating cement has dried, coat insulated surface with lagging adhesive, and apply 4 oz or 6 oz canvas jacket as required by pipe size.
      a. Lap canvas jacket on itself and adjoining pipe insulation at least 2".
      b. Size entire canvas jacket with lagging adhesive.

7. Piping Systems (below 250° F)
   a. Valves, fittings and flanges may be insulated with pre-molded PVC fitting jackets, with fibrous glass insulation inserts.
      1) The surface temperature of PVC fitting jacket not to exceed 150° F.

## 3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC FOAM INSULATION

A. Where possible, slip insulation over the pipe, and seal butt joints with adhesive.
   1. Where the slip-on technique is not possible, slit the insulation and install.
   2. Re-seal with adhesive, making sure the mating surfaces are completely joined.

B. Insulate fittings and valves with miter cut sections. Use templates provided by the manufacturer, and assemble the cut sections in accordance with the manufacturer's printed instructions.
   1. Insulate threaded fittings and valves with sleeved fitting covers. Overlap and seal the covers to the adjoining pipe insulation with adhesive.

C. Carefully mate and seal with adhesive all contact surfaces to maintain the integrity of the vapor barrier of the system.

D. Piping Exposed Exterior to a Building, Totally Exposed to the Elements:
   1. Apply flexible elastomeric foam insulation to piping with adhesive.
   2. Apply reinforcing membrane around piping insulation with adhesive or mastic.
   3. Adhesive Applied System: Apply two (2) coats of finish.
   4. Mastic Applied System: Apply another coat of mastic over reinforcing membrane.

## 3.7 INSTALLATION OF PVC JACKETING ON PIPING

A. Secure jacketing to insulated piping and seal with adhesive. All seams shall be secured flat.

B. Jacket fittings with preformed covers.

## 3.8 INSTALLATION OF METAL JACKETING ON PIPING

A. Secure jacketing to insulated piping with preformed aluminum snap straps and stainless steel strapping installed with special banding wrench.

B. Jacket fittings, valves and flanges with mitred sections of aluminum jacketing.
   1. Seal joints with sealant and secure with preformed aluminum bands.
   2. Factory fabricated, preformed, sectional aluminum fitting covers may be used in lieu of mitred sections of aluminum jacketing for covering fittings, valves and flanges.

## 3.9 FIELD QUALITY CONTROL

A. Field Samples: The Owner's Representative, may at his discretion, take field samples of

installed insulation for the purpose of checking materials and application. Contractor shall reinsulate sample cut areas.

## 3.10 EQUIPMENT INSULATION SCHEDULE

A. Unless factory insulated, contractor shall insulate the following with the same thickness and material as the piping system they serve:
   1. Domestic Water Softener Tanks
   2. RO Water Storage Tanks and Distribution Pumps

## 3.11 PIPING INSULATION SCHEDULE

A. Refer to Piping Application Schedule on Drawings for Piping Insulation Schedule.

B. Insulate all cold service and hot service piping, and appurtenances except where otherwise specified.

C. Schedule of items not to be insulated:
   1. Do not insulate the following items:
      a. Actual heat transfer surfaces.
      b. Chromium plated piping, unless otherwise specified.
      c. Flexible vibration eliminators.
      d. Water meters.
      e. Drains from heating equipment and appurtenances that flow to waste.
      f. Chemical feed piping.
      g. Safety and relief valves. Discharge piping from relief valves.
      h. Vent piping to atmosphere installed exposed in Mechanical Rooms, connected to the following: Blow-off tanks, flash tanks, condensate tanks.
      i. Flanges and unions in piping systems over 140° F.
      j. Float chambers and level controllers.
   2. Do not insulate mechanical equipment with a factory applied insulated steel jacket, unless specified otherwise.

D. Notes:
   1. Insulate cold condensate drain piping connected to drain pans under cooling coils within unit enclosure, except where over drain pans:

## 3.12 SCHEDULE OF METAL JACKETING FOR INSULATED PIPE

A. Piping Exterior to Building: Jacket insulated piping with circumferentially corrugated aluminum jacketing.
   1. Lap longitudinal and circumferential joints a minimum of 2”.
   2. Secure jacketing in place with 1/2" x 0.020” thick aluminum bands secured with aluminum wing type seals, on maximum 12” centers.
   3. Cover insulated fittings, valves, and offsets with mitered sections of jacketing. Seal joints with mastic, and secure with aluminum strapping and wing seals.

4. Factory fabricated, preformed fitting covers of same material as jacketing may be used instead of mitered jacketing.
5. Install jacketing so as to avoid trapping condensation and precipitation.

## 3.13 SCHEDULE OF PVC JACKETING FOR INSULATED PIPE

A. For exposed piping, install jacketing from floor to ceiling or from floor to first change of direction in riser, when such change in direction is a minimum of 9’-0” above finished floor, whichever is applicable.

B. Jacket exposed insulated piping in mechanical rooms and tunnels with PVC jacketing.

## 3.14 SCHEDULE OF ALUMINUM JACKETING FOR INSULATED PIPE

A. Jacket exposed insulated piping on roof with aluminum jacketing.

**END OF SECTION**

**SECTION 230800**

**COMMISSIONING OF HVAC**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide the following commissioning process requirements for HVAC & R systems, assemblies, and equipment as indicated by the Contract Documents.

B. Commissioning of this project shall meet the current adopted version of the International Energy Conservation Code.

C. Section includes commissioning process requirements for mechanical system, assemblies and equipment.

1.2 QUALITY ASSURANCE

A. Installer and Manufacturer Qualifications
   1. Installer shall have an established working relationship with Control System Manufacturer.
   2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

B. Commissioning Agent Qualifications
   1. The testing commissioning agent will need to have a certification that has been accredited by the American National Standards Institute (ANSI).

C. Regulatory Requirements
   1. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications.
      a. Current adopted version of the National Electric Code (NEC)
      b. Current adopted version of the International Building Code (IBC)
      c. Current adopted version of the International Mechanical Code (IMC)
      d. ANSI/ASHRAE 135 adopted version: Data Communication Protocol for Building Automation and Control Systems (BACNET)
      e. Current adopted version of the International Energy Conservation Code
      f. ASHRAE 90.1 adopted version: Energy Standard for Buildings

D. Start up of equipment and systems shall be done by or with a trained manufacturer’s representative who can check and report on all items such as installation, operation, and see that the equipment or system starts and operates properly.

E. Testing shall be performed at the convenience of the Owner and with the Owner's representatives present and the manufacturer's representative of the equipment and/or system present.

## 1.3 ABBREVIATIONS

A. The following are common abbreviations used in the Specifications and in the Commissioning Plan. Definitions are found in Section 1.5.

A/E- Architect and Design Engineers
CxA- Commissioning Authority
TC- Temperature Controls Contractor
CM- Construction Manager
Cx- Commissioning
Cx Plan- Commissioning Plan
EC- Electrical Contractor
GC- General Contractor
MC- Mechanical Contractor
OR- Owner's Representative
PC- Prefunctional Checklist
PM- Project Manager (of the Owner)
FPT- Functional Performance Test
TAB- Test and Balance Contractor

## 1.4 DEFINITIONS

A. Acceptance Phase: Phase of construction after startup and initial checkout when functional performance tests, O&M documentation review and training occurs.

B. Approval: Acceptance that a piece of equipment or system has been properly installed and is functioning in the tested modes in accordance with the contract documents.

C. Architect/Engineer (A/E): The prime consultant (architect) and sub-consultants who comprise the design team, generally the HVAC mechanical designer/engineer and the electrical designer/engineer.

D. Basis of Design (BOD): A document that records concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

E. Commissioning Authority (CxA): The entity identified by the OR/PM who leads, plans, schedules, and coordinates the commissioning team to implement the commissioning process.

F. Commissioning Plan: An overall plan that provides the structure, schedule and coordination planning for the commissioning process.

G. Construction Manager (CM): The manager contracted by the owner or architect. Generally responsible for the overall coordination of the project.

H. Contractors: The subcontractors to the GC who provide and install building components and systems.

I. Deferred Functional Tests: Tests that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.

J. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the contract documents (that is, does not perform properly or is not complying with the design intent).

K. Factory Testing: Testing of equipment on-site or at the factory by factory personnel.

L. Functional Performance Test (FPT): Test of the dynamic function and operation of equipment and systems using manual or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The CxA develops the functional test procedures in written form. The CxA performs or directs, coordinates, oversees, and documents the actual testing. The contractor performs the functional tests when requested by the CxA. FPT's are performed after startup are complete.

M. General Contractor (GC): The prime contractor for this project. Generally responsible for the overall coordination of the project.

N. Monitoring: The recording of parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of control systems.

O. Observation/Issue Log: The log of all commissioning related items that require current or future attention. This form is used to track all action taken on each item listed overtime until the items are resolved.

P. Owner's Project Requirements (OPR): A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

Q. Phased Commissioning: Commissioning that is completed in phases (by floors, for example) due to the size of the structure or other scheduling issues, in order to minimize the total construction time. Commissioning shall be provided for each phase according to the schedule for that phase. Some repetition and/or remobilization may be required.

R. Sampling: Functionally testing only a fraction of the total number of identical or near identical pieces of equipment.

S. Startup: The initial starting or activating of dynamic equipment.

T. Trending: Monitoring using the building control system.

U. Warranty Period: Warranty period for entire project, including equipment components. Warranty begins at substantial completion and extends for at least one year, unless specifically noted otherwise in the contract documents and accepted submittals.

## 1.5 CONTRACTOR'S RESPONSIBILITIES

A. The Contractor's commissioning responsibilities are as follows (all references apply to commissioned systems and equipment only):
   1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation.
   2. Cooperate with the CxA for resolution of issues recorded in the observation/issue log.
   3. Attend commissioning team meetings.
   4. Provide current project construction schedule, including any updates to the schedule, to the CxA for planning.
   5. Include the cost of commissioning assistance in the contract price.
   6. Address incomplete work before functional performance testing.
   7. Assist the CxA as necessary in the seasonal or deferred testing and deficiency corrections required by the specifications.
   8. Provide skilled technicians to execute startup of equipment. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
   9. Provide skilled technicians to participate and assist under the direction of the CxA for specified equipment. Provide manufacturer's representative as required and as specified in the specification.
   10. Mechanical Contractor shall submit approved equipment data sheets on systems to be commissioned to the CxA for review.
   11. Control Contractor shall submit all approved equipment data sheets, approved control drawings and approved sequence of operations to the CxA.
   12. TAB Contractor shall submit certification documentation, TAB procedures plan, and preliminary project layout (which shall include an inventory of required flow rates for each air and hydronic system).
   13. Provide all training as specified.

## 1.6 CxA'S RESPONSIBILITIES

A. The CxA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CxA may assist with problem-solving, non-conformance or deficiencies, but ultimately that responsibility resides with the CM and the A/E. The primary role of the CxA is to develop and coordinate the execution of a testing, observe and document performance—that systems are functioning in accordance with the documented design intent and contract documents. The contractors will provide all tools or the use of tools to start, check-out and functionally test equipment and systems.
   1. Coordinates and directs the commissioning activities using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.
   2. Coordinate the commissioning work with the CM to ensure that commissioning activities are being scheduled into the master schedule.
   3. Revise, as necessary, the commissioning plan.
   4. Plan and conduct a commissioning kickoff meeting and other commissioning meetings.

5. Request and review additional information required to perform commissioning tasks, including balancing reports, O&M materials, contractor start-up and checkout procedures.
6. Write the functional performance test procedures for equipment and systems. This may include energy management control system trending, stand-alone datalogger monitoring or manual functional testing.
7. Analyze any functional performance trend logs and monitoring data to verify performance.
8. Perform or direct, witness and approve manual functional performance tests. Coordinate retesting as necessary until satisfactory performance is achieved.
9. Maintain the observation/issue log and distribute to the team.
10. Review the training of the owner's operating personnel when defined in the contract documents.
11. Provide preliminary and final commissioning reports.
12. Perform or direct, witness, and supervise required seasonal or deferred testing and deficiency corrections. Seasonal testing shall include peak summer and peak winter operation at a minimum.

## 1.7 COMMISSIONING DOCUMENTATION

A. The CM and appropriate contractors/subcontractors, including their manufacturer vendors, shall provide the following information to the CxA for inclusion in the commissioning plan:
   1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
   2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
   3. Process and schedule for completing prefunctional checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
   4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
   5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
   6. Test and inspection reports and certificates.
   7. Testing, adjusting, and balancing reports.
   8. Laser alignment reports.
   9. Completion report of pipe cleaning, flushing hydrostatic testing and chemical water treatment.

B. The CxA shall provide and include the following documentation:
   1. Commissioning plan, including narrative of activities, personnel lists, and equipment to be tested.
   2. Functional performance testing procedures for each series of tests. Submittals shall include samples of data reporting sheets that will be part of the reports.
   3. Observations and issues logs.
   4. Preliminary commissioning report listing deficiencies from testing and deferred seasonal tests to be completed.

5. Final commissioning report; including testing of seasonal design conditions, full outdoor air conditions, and other relevant measurable criteria.

1.8 SYSTEMS TO BE COMMISSIONED

A. The following checked systems will be commissioned in this project:
   1. HVACR Systems
   2. Energy Management Systems (BAS, EMS, DDC)

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-STARTUP VERIFICATION (PSV)

A. Prior to the installation of each piece of equipment, verify that equipment arriving on site is consistent with what was required.

B. Certify that HVAC & R systems, subsystems, and equipment have been installed according to the Contract Documents.

C. Certify that HVAC & R instrumentation and control systems have been installed, connected, calibrated and are ready for start-up procedures.

D. Inspect and verify the position of each device and interlock.

3.2 STARTUP TESTING AND VERIFICATION (STV)

A. Prior to the startup of each piece of equipment, verify that equipment installed is consistent with what was required.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. 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. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

E. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

## 3.3 TESTING, ADJUSTING AND BALANCING (TAB) VERIFICATION

A. Prior to performance of TAB Work, provide copy of completed system readiness checklists, preliminary report (comprehensive project layout in electronic format), and certification documentation to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

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

## 3.4 FUNCTIONAL PERFORMANCE TESTING REQUIREMENTS (FPT)

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Prior to the functional performance testing of each piece of equipment, verify that equipment has been correctly brought online and TAB report has been accepted (ie, verify that the STV for each piece of equipment has been completed and accepted)

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. All members of the Cx team shall provide technicians, instrumentation, and tools as required in the respective FPT test format.

E. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

F. 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.

G. The CxA along with the HVAC&R Subcontractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, for HVAC&R systems, subsystems, and equipment.

H. Tests will be performed using design conditions whenever possible.

I. 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.

J. The CxA may direct that set points be altered when simulating conditions is not practical.

K. 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.

L. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

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

## 3.5 HVAC & R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls." The HVAC&R Contractor shall assist the CxA with preparation of testing plans. Testing of equipment shall include all modes of operation according to the controls sequences: At a minimum, equipment tests shall include:
   1. Full-load and part-load design conditions.
   2. Economizer operation for all equipment scheduled with airside or waterside economizer requirements.
   3. Alarming capabilities in the drawings or required by the manufacturer safeties.
   4. Operation shut-down and start-up upon loss of power and restoration of power.
   5. Automatic equipment switching and other forms of redundancy or automatic back-up.

B. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
   1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.

2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

C. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

D. HVAC & R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, and hydronic distribution systems; and other distribution systems, including HVAC & R terminal equipment and unitary equipment.

## 3.6 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Documentation: The CxA shall perform or direct, witness, and document the results of all functional performance tests using the specific procedural forms developed for that purpose. The CxA will include the filled out forms in the final report.

B. Non-conformance

1. The CxA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the CM and the contractors in the observation/issue log.

2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA.

3. As testing progresses and deficiencies are identified, the CxA shall discuss such deficiencies with the commissioning team and responsible contractors.
   a. When there is no dispute on the deficiency and the contractor accepts responsibility to correct the deficiency, the CxA will document it in the observation/issue log and require the responsible contractor to respond to the item in the log. The contractor shall reschedule the test and the test is repeated by the CxA.
   b. If there is a dispute about a deficiency, specifically whether or not it is a deficiency, the dispute shall be documented in the observation/issue log. Resolutions will be made at the lowest management level possible. Other parties will be brought into the resolution discussions as needed. Final authority is with the A/E. Final acceptance authority is with the OR/PM. The CxA will document the resolution process. Once the resolution has been accepted, the contractor corrects the deficiency, responds in the observation/issue log certifying the equipment is ready to be retested, and sends the log back through the CM to the CxA. The contractor shall reschedule the test and the test is repeated by the CxA until satisfactory performance is achieved.

C. Cost of Retesting
   1. The cost for the contractor to retest a functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the CM.

D. Failure Due to Manufacturer Defect: If 10%, or three, whichever is greater, of identical pieces of equipment fail to perform to the contract documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance specification, all identical units may be considered unacceptable by the A/E or CxA. In such case, the contractor shall provide the OR/PM or CM with the following:
   1. Within one week of notification from the OR/PM or CM, the contractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the OR/PM or CM within two weeks of the original notice.
   2. Within two weeks of the original notification, the contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
   3. The A/E will determine whether a replacement of all identical units or a repair is acceptable.
   4. Two examples of the proposed solution will be installed by the contractor and the A/E will be allowed to test the installations for up to one week, upon which the A/E will decide whether to accept the solution.
   5. Upon acceptance, the contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

E. Approval: The CxA notes each satisfactorily demonstrated function on the test form. Final approval of the functional tests is made after review by the CxA and by the OR/PM, following recommendations by the A/E.

F. Final documents shall be compiled and provided to the owner within 90 days of the certificate of occupancy. The CxA, CM, subcontractors, A/E shall work together to provide all required documents. At a minimum the documents shall include the final version of any as-built construction documents, O&M materials, balancing reports, final commissioning reports, contractor start-up and checkout procedures, and lighting system functional testing from the lighting controls factory testing.

**END OF SECTION**

**SECTION 230900**

**DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following HVAC Control System indicated by the Contract Documents with supplementary items necessary for proper installation.

B. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and an operator workstation or web server. The system shall control or monitor all equipment specified on the Contract Drawings. See the temperature controls responsibility matrix on the drawings.

C. Equipment Included in This Section
   1. Products (not furnished or installed but integrated with the Work of this section)
      a. Coordination Meeting: The Installer furnishing the DDC network shall meet with the Installer(s) furnishing mechanical equipment, VFD's, fire alarm, and controllers to coordinate details of the interface between these products and the DDC network. The Owner or his designated representative shall be present at this meeting. Each Installer shall provide the Owner and all other Installers with details of the proposed interface hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories. The purpose of this meeting shall be to insure there are no unresolved issues regarding the integration of these products into the DDC network. Submittals for these products shall not be approved prior to the completion of this meeting.

1.2 REFERENCES

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. Related Work
   1. Section 230500 - Common Work Results for HVAC
   2. Section 260500 - Common Work Results for Electrical
   3. Section 260523 – Control Cables
   4. Section 232923 or 262923 – Variable Frequency Drives
   5. Section 280000 - Electronic Safety and Security (includes Fire and Smoke)

1.3 SUBMITTALS

A. Product Submittal Requirements: Provide copies of Shop Drawings and other submittals on hardware, software, and equipment to be installed or furnished. Begin no work until submittals have been approved for conformity with design intent. Provide drawings in .PDF format. When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other means. Clearly reference covered specification and drawing on each submittal. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work.
   1. Direct Digital Control System Hardware
      a. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
      b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions.
      c. Diagrams indicating field sensor and controller locations.
   2. Central System Hardware and Software
      a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
      b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions.
      c. Schematic diagrams of control, communication, and power wiring for central system installation. Show interface wiring to control system.
   3. Controlled Systems
      a. Riser diagrams showing control network layout, communication protocol, and wire types.
      b. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
      c. Instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
      d. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system. List I/O points and software points specified on Drawings. Indicate alarmed and trended points.
      e. Submittal of control sequences should include the actual control sequence proposed for this project, not a copy of the sequence included in the construction documents. If the actual sequence is not available during the initial submission of the shop drawings it can be issued for review during construction prior to equipment startup.

B. Control Point Integration List
   1. Contractor to provide a master list of all control points for each piece of mechanical equipment with packaged controls.

C. Control Point Verification List
   1. Contractor to provide a list containing all control points after substantial completion. The list shall include the following:

a. Operation of the control point was operating as needed per the contract documents / shop drawings.
b. Who verified the point operation.
c. Date and time of verification.

D. Training Materials: Provide course outline and materials for each class at least four (4) weeks before first class.

E. Project Record Documents. Submit three (3) copies of record (as-built) documents upon completion of installation for approval prior to final completion. Submittal shall consist of:
1. Provide three (3) copies of project record drawings. As-built versions of submittal shop drawings provided on a USB flash drive (file format: .PDF) and prints of each drawing on 11" x 17" paper.
2. Completed versions of reports, checklists, and trend logs used to meet requirements of Control System Demonstration and Acceptance Section.
3. Operation and Maintenance (O&M) Manual: Printed, electronic, or online help documentation of the following:
   a. As-built versions of submittal product data.
   b. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
   c. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
   d. Programming manual or set of manuals with description of programming language and syntax, statements for algorithms and calculations used, point database creation and modification, program creation and modification, and editor use.
   e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
   f. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
   g. Graphic files, programs, and database on USB drive.
   h. List of recommended spare parts with part numbers and suppliers.
   i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
   j. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
   k. Licenses, guarantees, and warranty documents for equipment and systems.
   l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

## 1.4 QUALITY ASSURANCE

A. Installer and Manufacturer Qualifications
   1. Installer shall have an established working relationship with Control System Manufacturer.
   2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

B. Regulatory Requirements
   1. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications.
      a. Adopted version of the National Electric Code (NEC)
      b. Adopted version of the International Building Code (IBC)
      c. Adopted version of the International Mechanical Code (IMC)
      d. ANSI/ASHRAE 135 (adopted version): Data Communication Protocol for Building Automation and Control Systems (BACNET)
      e. Adopted version of the International Energy Conservation Code
      f. ASHRAE 90.1 (adopted version): Energy Standard for Buildings

C. Components shall not contain any mercury unless written permission is obtained from Owner.

## 1.5 WARRANTY

A. Warrant labor and materials for specified control system free from defects for a period of twelve (12) months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within twenty-four (24) hours of Owner's warranty service request.

B. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period. These warranty dates shall be submitted to the Owner.

C. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.

D. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

1.6 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:
   1. Graphics
   2. Record drawings
   3. Database
   4. Application programming code
   5. Documentation

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers.

B. Graphics shall depict each of the building systems controlled. An overall building floor plan and individual rooms shall be accessible using a point and click graphic.

C. The system shall directly control HVAC equipment as specified on the Drawings. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints as specified in the sequence.

D. A web-based interface shall be used to access the controls system through a conventional web browser on each PC connected to the network

E. Provide for future system expansion to include monitoring of occupant card access, fire alarm, and lighting control systems.

2.2 APPROVED CONTROL SYSTEMS

A. Trane Controls or preapproved equal

2.3 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five (5) years after completion of this contract.

2.4 SYSTEM PERFORMANCE

A. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator web-based interface.

1. A graphic with twenty (20) dynamic points shall display with current data within ten (10) seconds.
2. A graphic with twenty (20) dynamic points shall update with current data within eight (8) seconds and shall automatically refresh every fifteen (15) seconds.
3. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within six (6) seconds.
4. Devices shall react to command of a binary object within two (2) seconds. Devices shall begin reacting to command of an analog object within two (2) seconds.
5. An object that goes into alarm shall be annunciated at the workstation within fifteen (15) seconds.
6. Custom and standard applications shall be capable of running as often as once every five (5) seconds. Select execution times consistent with the mechanical process under control.
7. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.
8. System shall report values with minimum end-to-end accuracy listed in Table 230900-1.
9. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 230900-2.

Table 230900-1: Reporting Accuracy

| Measured Variable | Reported Accuracy |
|---|---|
| Space Temperature | ±1ºF |
| Ducted Air | ±1ºF |
| Outside Air Temperature | ±2ºF |
| Dew Point Temperature | ±3ºF |
| Water Temperature | ±1ºF |
| Temperature Difference (Delta-T) | ±0.25ºF |
| Relative Humidity | ±5% RH |
| Airflow (terminal) | ±10% of full scale (Note 1) |
| Airflow (measuring stations) | ±2% of full scale |
| Airflow (pressurized spaces) | ±3% of full scale |
| Air Pressure (ducts) | ±0.1 in. w.g. |
| Air Pressure (space) | ±0.01 in. w.g. |
| Water Flow | ±0.2% of full scale (Note 2)<br>±1.0% of full scale (Note 3) |
| Water Pressure | ±2% of full scale (Note 4) |
| Electrical (A, V, W, Power Factor) | ±1% of reading (Note 5) |
| Carbon Monoxide (CO) | ±3% of reading |
| Carbon Dioxide ($CO_2$) | ±50 ppm |

Notes:

1. 1 Accuracy applies to 10% - 100% of scale
2. For flanged style water flow meters.
3. For insertion style water flow meters.
4. For both absolute and differential pressure
5. Not including utility-supplied meters

Table 230900-2: Control Stability and Accuracy

| Controlled Variable | Control Accuracy | Range of Medium |
|---|---|---|
| Air Pressure | ±0.2 in. w.g.<br>±0.01 in. w.g. | 0 to 6 in. w.g.<br>-0.1 to 0.1 in. w.g. |
| Airflow | ±10% of full scale | |
| Space Temperature | ±2.0ºF | |
| Duct Temperature | ±3ºF | |
| Relative Humidity | ±5% RH | |
| Fluid Pressure | ±1.5 psi<br>±1.0 in. w.g. | 1 to 150 psi<br>0 to 50 in. w.g. differential |

## 2.5 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a unified control network. A gateway (translator) shall communicate with third-party equipment furnished or installed by others.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. System shall automatically synchronize controller time clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

F. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.

2.6 OPERATOR INTERFACE

A. Web-based interface shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information.

B. Operator interface shall allow each authorized operator to execute the following functions as a minimum:
   1. System shall require user name and password to log in to operator interface.
   2. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
   3. Operators shall be able to:
      a. View controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.
      b. View scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.
      c. View a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
      d. View a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
      e. Run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
      f. View controller status, to reboot each controller, and to download new control software to each controller.
   4. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

C. System Software
   1. Operating System: Web server or workstation shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Windows.
   2. System Graphics:
      a. Operator interface shall be graphically based.
      b. Each piece of equipment shall include at least one (1) graphic or occupied zone and indicate animations for fans, pumps, dampers, and compressors such that it is intuitive when they are running or when they are stopped.
      c. Each system graphic shall include a button/tab to a display of the applicable sequence of operation.
      d. Floorplan layouts showing rooms and temperature are required. Indicate thermal comfort on the floorplan using dynamic colors to represent zone temperature relative to zone setpoint.
      e. By clicking on the temperature icon, this will direct you to the dedicated graphic with all related information on that piece of equipment i.e. VAV box, AHU, unit heater, etc.

f. When the sequence of operation state (adj.), all of these points shall be adjustable by the user from the graphics, i.e. DAT, zone temps, OA enable temps, etc.
g. All overridden points shall be highlighted with a unique color to clearly indicate overridden.

D. System Tools: System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.
1. Each web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Operators shall be able to download memory from the system database to each controller.
3. Context-sensitive online help for each tool shall assist operators in operating and editing the system.
4. System shall require a user name and password to view, edit, add, or delete data.
   a. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object.
   b. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
   c. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
5. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).
6. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
7. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
   a. Log date and time of alarm occurrence.
   b. Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm from the workstation or web browser interface.
   c. Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
   d. At minimum, direct alarms shall be able to log, print, start programs, display messages, send e-mail, send page, send text message, and audibly annunciate. BMS contractor shall coordinate implementation of this feature with the owner as part of the work of this project.
   e. Any attribute of any object in the system may be designated to report an alarm.
   f. The system shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions.
   g. All specified alarms shall be shown on the correct system graphic, turn red and flash.
   h. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.

8. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk.

9. Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.

10. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

11. Furnish the following standard system reports:
    a. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. System shall log the following to a database or text file and shall retain data for an adjustable period:
        1) Alarm History.
        2) Operator shall be able to select trends to be logged.
        3) At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

12. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.

13. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.

14. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded.

E. Portable Operator's Terminal: Provide all necessary software to configure a Windows OS based laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

## 2.7 CONTROLLER SOFTWARE

A. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. System shall provide the following schedule options as a minimum:
   1. Provide separate schedules for each day of the week. Each schedule shall be able to include up to five (5) occupied periods (five (5) start-stop pairs or ten (10) events).
   2. Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.
   3. Operator shall be able to define twenty-four (24) special or holiday schedules of varying length on a scheduling calendar that repeats each year.

C. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

D. Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

E. System shall provide an algorithm that can totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit.

F. Remote Communication
   1. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

G. Demand Limiting
   1. System shall monitor building power consumption from building power meter pulse generator signals or from building feeder line watt transducer or current transformer.
   2. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified. When demand drops below adjustable levels, system shall restore loads as specified.

H. Maintenance Management
   1. System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits.

I. Energy Calculations
   1. System shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
   2. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to fifteen (15) minutes, thirty (30) minutes, or sixty (60) minutes.

## 2.8 CONTROLLERS

A. General. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified.

B. Communication
   1. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
   2. Each piece of equipment specified on Drawings to controlled or monitored by DDC system shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

C. Controller hardware shall be suitable for anticipated ambient conditions.
   1. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32° F to 120° F.
   2. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -20° F to 140° F.

D. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.

E. Controllers that perform scheduling shall have a real-time clock.

F. Serviceability
   1. Controllers shall have diagnostic LEDs for power, communication, and processor.
   2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.
   3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

G. Memory
   1. Controller memory shall support operating system, database, and programming requirements.
   2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
   3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

H. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

## 2.9 INPUT AND OUTPUT INTERFACE

A. General: Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

C. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

D. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two (2)-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

E. Control three (3)-point floating electronic actuators without feedback with tri-state outputs (two (2) coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

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

## 2.10 AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers
   1. Acceptable Manufacturers:
      a. Ruskin
      b. Tamco
      c. Greenheck
      d. Siemens
      e. Johnson Controls
   2. Type: Dampers shall be low-leakage, high performance type with linear airflow performance.
   3. Frame: Damper frames shall be extruded aluminum with reinforced corner bracing. Provide insulated frames with thermal break as scheduled on the Drawings.
   4. Blades: Damper blades shall not exceed 8 in. in width or 48 in. in length. Blades shall be airfoil type suitable for 2000 fpm face velocity.
   5. Shaft Bearings: Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.

6. Seals: Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Blade seals shall be AMCA Class I and leak no more than 8 cfm per $ft^2$ at 4 in. w.g. differential pressure.
7. Damper sections shall not exceed 48" – 60". Each section shall have at least one (1) damper actuator.
8. Dampers shall have exposed linkages.

B. Electric Damper and Valve Actuators
1. Stall Protection: Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.
2. Spring-return Mechanism: Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).
3. Signal and Range: Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in the Input and Output Interface paragraph above.)
4. Wiring: 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
5. Manual Positioning: Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb torque capacity shall have a manual crank.

C. Binary Temperature Devices
1. Low-Voltage Space Thermostats: Low-voltage space thermostats shall be 24 V, bimetal-operated, with adjustable or fixed anticipation heater, digital temperature and setpoint display, 55° F - 85° F setpoint range, 2° F maximum differential, and vented ABS plastic cover.
2. Line-Voltage Space Thermostats: Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 55° F - 85° F setpoint range, 2° F maximum differential, and vented ABS plastic cover.
3. Low-Limit Thermostats (Freezestats): Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 20 ft. long. Element shall sense temperature in each 1 ft. section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only. Sensor shall be installed so the entire coil has coverage (1ft. of sensor / 1 sq. ft. of coil and provide multiple units if necessary to meet this requirement). The sensor shall not be installed more than 6" from the edge of the coil. The location of the reset head must be outside the plenum wall and at the highest point of the assembly. The sensing bulb shall be sloped continuously downward from the reset head.

D. Temperature Sensors
1. Type: Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
2. Duct Sensors: Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 5 ft in length per 10 $ft^2$ of duct cross-section.

3. Immersion Sensors: Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
4. Space Sensors: Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.
5. Differential Sensors: Provide matched sensors for differential temperature measurement.

E. Humidity Sensors
1. Duct and room sensors shall have a sensing range of 20% - 80%.
2. Duct sensors shall have a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 10% - 95% RH and shall be suitable for ambient conditions of 40° F - 170° F.
4. Humidity sensors shall not drift more than 1% of full scale annually.

F. Flow Switches: Flow-proving switches shall be differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
1. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

G. Relays
1. Control Relays: Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time Delay Relays: Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

H. Override Timers
1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

I. Current Transmitters
1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two (2)-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

J. Voltage Transmitters
1. AC voltage transmitters shall be self-powered single-loop (two (2)-wire) type, 4-20 mA output with zero and span adjustment.

2. Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

K. Power Monitors
1. Power monitors shall be three (3)-phase type and shall have three (3)-phase disconnect and shorting switch assembly, UL listed voltage transformers, and UL listed split-core current transformers.
2. Power monitors shall provide selectable output: Rate pulse for kWh reading or 4-20 mA for kW reading. Power monitors shall operate with five (5) A current inputs and maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

L. Current Switches
1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

M. Pressure Transducers
1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.
3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 150 psi. Transducer shall have 4-20 mA output, suitable mounting provisions, and block and bleed valves.
4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 150 psi. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall have 4-20 mA output, suitable mounting provisions, and five (5)-valve manifold.

N. Differential Pressure Switches:
1. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

O. Water Flow Measuring (In-Line, Flanged):
1. No moving parts and capable of bi-directional measurement. Sensing technology utilizes two electromagnetic velocity-measuring elements. Paddle or turbine meters are not acceptable.
2. Body shall be stainless steel with ANSI Class 150 flanges. Body liner to be PTFE or manufacturer recommendation for temperature and fluid. Electrodes to be type 316 stainless steel.
3. Fluid flow measuring sensors shall be installed with a minimum straight pipe of three pipe diameters upstream and two pipe diameters downstream, or according to the sensor manufacturer’s recommendations.
4. Sensor accuracy shall be +/- 0.25% of the flow reading over the entire range of fluid flow measured with a minimum conductivity of 5 micro-Siemens per centimeter.
5. Transmitter shall be either integral or remote to meter. Transmitter housing to be IP67 rated in a NEMA 4X enclosur with backlit LCD display. Installation shall provide ease of access for maintenance.

6. Transmitter shall perform all internal calculations to output to the FMS the GPM readings.
7. Manufacturer standard three year warranty.

P. Water Flow Measuring (Insertion type):
1. No moving parts and capable of bi-directional measurement. Sensing technology utilizes two electromagnetic velocity-measuring elements. Paddle or turbine meters are not acceptable.
2. For pipe sizes of 1-1/4" and larger. Probe to be wet tappable allowing insertion and removal from pipe well without system shutdown. Electrodes to be type 316 stainless steel.
3. Provide with insertion depth gage and installation kit including full port, stainless steel, isolation valve.
4. Fluid flow measuring sensors shall be installed with a minimum straight pipe of 10 pipe diameters upstream and five pipe diameters downstream, or according to the sensor manufacturer's recommendations.
5. Sensor accuracy shall be +/- 1.0% of the flow reading over the entire range of fluid flow measured with a minimum conductivity of 25 micro-Siemens per cm.
6. Transmitter shall be integral. Transmitter housing shall be a NEMA 4 enclosure with backlit LCD display. Installation shall provide ease of access for maintenance. Installation shall provide ease of access for maintenance.
7. Transmitter shall perform all internal calculations to output to the FMS the GPM readings.
8. Manufacturer standard three year warranty.

Q. Air Flow Measuring
1. Airflow measuring sensors shall be installed at fan inlet whenever possible and shall be capable of continuously measuring the air handling capacity (air volume) of the respective centrifugal, plug, or vane-axial fan(s).
2. Duct mounted: Thermal dispersion type. Units shall be provided complete with differential pressure transducers, temperature compensation, square root extraction. Unit shall perform all internal calculations to output to the FMS the CFM readings. Provide straight duct before and after device according to the sensor manufacturer's recommendations. Provide access door in ductwork adjacent to sensors.
3. Sensor accuracy shall be +/- 2% of the airflow reading over the entire range of airflow measured.
4. The transmitter shall be capable of displaying the airflow and temperature readings of individual sensors on the LCD display.

R. Gas Detection Equipment
1. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 32 to 104° F and calibrated for 0 to 2%, with continuous or averaged reading, 4-20 mA output, for wall mounting.
2. Carbon Monoxide Detectors: Refer to Specification 230913.
3. Oxygen Depletion Detectors: Refer to Specification 230913. Single detector using long life zirconium oxide sensors rated for a minimum of 8 years runtime; suitable over a temperature range of -40 to 134 F; rated for nitrogen gas compatibility; with dual level alarm relays (4-20 mA output) pre-calibrated to 18.0% and 19.5% O2; integral audible alarm; 24 VDC powered; and wall mounted.

S. Local Control Panels
   1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.
   2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.
   3. Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

## 2.11 WIRING

A. General Installation and Equipment Requirements
   1. The Controls Installer as noted in the scope matrix shall provide and install conduit, hangers, supports, wiring, and cable to meet the requirements noted in applicable sections of the Division 26 specifications. This requirement will maintain a consistent level of quality for all wiring systems in the building.
   2. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Architect or Engineer for resolution before starting rough-in work.

B. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

C. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate temperature controls work with work of others. ATC shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

## 3.2 PROTECTION

A. Controls Contractor shall protect against and be liable for damage to work and to material caused by Controls Contractor's work or employees.

B. Controls Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of dust and foreign objects.

## 3.3 COORDINATION

A. Site
   1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.
   2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Test and Balance
   1. Provide Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing.
   2. Train Test and Balance Contractor to use control system interface tools.
   3. Test and Balance Contractor shall return tools undamaged and in working condition at completion of testing and balancing.

C. Life Safety
   1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified.
   2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified. Provide wiring to dampers as required.
   3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.

D. Coordination with Other Controls: Integrate with and coordinate controls and control devices furnished or installed by others as follows.
   1. Communication media and equipment shall be provided as specified.
   2. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation described on Drawings regardless of where within the contract documents those products are described.
   3. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
   4. Controls Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.
   5. The temperature control contractor shall provide all necessary additional sensors to execute all sequences as indicated on the construction documents. Coordinate additional requirements with equipment manufacturer.

## 3.4 GENERAL WORKMANSHIP

A. Install equipment, piping, conduit, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

D. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

E. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

F. Continually monitor field installation for code compliance and workmanship quality.

## 3.5 WIRING

A. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26, and manufacturer's recommendations. Where the requirements of this section differ from Division 26, this section shall take precedence.

B. Use color-coded conductors throughout.

C. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

D. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

E. Low-voltage wiring shall meet NEC Class 2 requirements. Subfuse low-voltage power circuits as required to meet Class 2 current limit.

F. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

G. NEC Class 2 (current-limited) wires not in conduit but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

H. Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 10 ft. intervals.

I. Use structural members to support or anchor plenum cables without conduit. Do not use ductwork, electrical conduits, piping, or ceiling suspension systems to support or anchor cables.

J. Verify entire network's integrity following cable installation using appropriate tests for each cable.

K. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

L. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

M. Label communication wiring to indicate origination and destination.

N. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

O. NEC Class 1 (line voltage) wiring shall be UL listed in approved conduit as specified by NEC and Division 26.

P. Install wiring in conduit where subject to mechanical damage and at levels below 10ft in mechanical, electrical, or service rooms.

Q. Install Class 1 and Class 2 wiring in separate conduits. Install communication wiring in separate conduits and enclosures from other wiring.

R. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

S. Do not install wiring in conduit containing pneumatic tubing.

T. Secure conduits with conduit clamps fastened to structure and spaced according to code requirements. Conduits and pull boxes shall not be hung on or attached to ductwork, electrical conduits, piping, or ceiling suspension systems.

U. Size conduit and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

V. Include one (1) pull string in each conduit 1 in. or larger.

W. Conceal conduits except within mechanical, electrical, or service rooms. Maintain minimum clearance of 6 in. between conduit and high-temperature equipment such as steam pipes or flues.

X. Install insulated bushings on conduit ends and enclosure openings. Seal top ends of vertical conduits.

Y. Flexible metal conduits and liquid-tight flexible metal conduits shall not exceed 3 ft in length and shall be supported at each end. Do not use flexible metal conduit less than 1/2 inch. Use liquid-tight flexible metal conduits in areas exposed to moisture including chiller and boiler rooms.

Z. Install conduit rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join conduit sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

3.6 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Install all controls devices, sensors, & equipment that is operable or has user adjustment at 42" above finished floor. Dimensions shall be measured from the floor level to the centerline of the device.

E. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

F. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

G. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide one (1) ft of sensing element for each one (1) $ft^2$ of coil area.

H. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

I. Install outdoor air temperature sensors on north wall at designated location with sun shield.

J. Differential Air Static Pressure
   1. Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
   2. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.
   3. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.
   4. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.
   5. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

## 3.7 ACTUATORS

A. General: Mount actuators and adapters according to manufacturer's recommendations.

B. Electric and Electronic Damper Actuators. Mount actuators directly on damper shafts. Do not link actuators, no jackshafting.
   1. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
   2. To compress seals when spring-return actuators are used on normally closed dampers, power the actuator to approximately 5° open position, manually close the damper, then tighten linkage.
   3. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
   4. Provide necessary mounting hardware and linkages for actuator installation.

C. Valve Actuators: Connect actuators to valves with adapters approved by actuator manufacturer.

## 3.8 WARNING LABELS

A. Affix permanent warning labels to all equipment that can be automatically started by the control system.
   1. Label: Labels shall use white lettering (18-point type or larger) on a red background. Size labels such that they are readily visible when approaching equipment for service.
   2. Install labels on equipment in locations of moving parts or electrical hazards such as access doors air handler fan sections, duct mounted heater control panels, pump shaft coupling guards, etc.
   3. Warning labels shall read as follows:

C A U T I O N
This equipment is operating under automatic control and may start or stop at any time without warning.
Switch disconnect to "Off" position before servicing.

B. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
   1. Labels shall use white lettering (twelve (12)-point type or larger) on a red background.
   2. Warning labels shall read as follows:

C A U T I O N
This equipment is fed from more than one (1) power source with separate disconnects.
Disconnect all power sources before servicing.

## 3.9 IDENTIFICATION OF HARDWARE AND WIRING

A. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within two (2) inches of termination.

B. Permanently label or code each point of field terminal strips to show instrument or item served.

C. Label control panels per Mechanical Identification specification.

D. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

E. Label room sensors (not thermostats) related to terminal boxes or valves with nameplates.

F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

G. Naming convention shall match Contract Drawings.

H. Label identifiers shall match record documents.

## 3.10 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.
   1. Calibrate and prepare for service each instrument, control, and accessory equipment furnished under the scope of the Contract.
   2. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
   3. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
   4. Verify that binary output devices such as relays, solenoid valves, two (2)-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
   5. Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
   6. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
   7. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
   8. Alarms and Interlocks
      a. Check each alarm with an appropriate signal at a value that will trip the alarm.
      b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
      c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

## 3.11 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration: Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Control System Checkout and Testing. Owner will witness demonstration. Provide ten (10) days' notice prior to starting demonstration. Provide Engineer with log documenting completion of startup tests.
   1. Complete approved checklists and forms for each system as part of system demonstration.
   2. Demonstrate actual field operation of each specified sequence of operation. Provide at least two (2) persons equipped with two (2)-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
   3. Demonstrate compliance with sequences of operation through each operational mode.
   4. Demonstrate complete operation of operator interface.
   5. Demonstrate each of the following.
      a. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
      b. Building fire alarm system interface.
      c. Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the sequence of operation. Each log shall cover three (3) forty-eight (48)-hour periods and shall have a sample frequency not less than ten (10) minutes or as specified.
   6. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

B. Acceptance
   1. After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.

## 3.12 CLEANING AND REPAIR

A. On completion of Work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

B. Clean the outside of all cabinets and sensor enclosures.

3.13 TRAINING

A. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

B. Training shall enable students to accomplish the following objectives.
   1. Proficiently operate system
   2. Understand control system architecture and configuration
   3. Understand DDC system components
   4. Understand system operation, including DDC system control and optimizing routines (algorithms)
   5. Operate workstation and peripherals
   6. Log on and off system
   7. Access graphics, point reports, and logs
   8. Adjust and change system setpoints, time schedules, and holiday schedules
   9. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
   10. Understand system drawings and Operation and Maintenance manual
   11. Understand job layout and location of control components
   12. Access data from DDC controllers
   13. Operate portable operator's terminals
   14. Configure and run reports
   15. Create and change system graphics
   16. Create, delete, and modify alarms, including configuring alarm reactions
   17. Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
   18. Add, remove, and modify system's physical points
   19. Create, modify, and delete application programming
   20. Add operator interface stations
   21. Add a new controller to system
   22. Download firmware and advanced applications programming to a controller
   23. Configure and calibrate I/O points
   24. Maintain software and prepare backups
   25. Interface with job-specific, third-party operator software
   26. Add new users and understand password security procedures

C. Divide presentation of objectives into three (3) sessions. Participants will attend one (1) or more of sessions, depending on knowledge level required.

D. Provide one (1) copy of training manual for each student.

E. Provide complete training for each shift of staff.

F. Include a minimum of eight (8) total hours of on-site training in bid.

G. Instructors shall be factory-trained and experienced in presenting this material.

H. Perform classroom training using a network of working controllers, representative of installed hardware.

**END OF SECTION**

**SECTION 230913**

**AIR QUALITY MONITORING DEVICES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following air quality monitoring systems and devices indicated by the Contract Documents with supplementary items necessary for proper installation.
   1. Engine Exhaust Detection System

1.2 REFERENCES

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
   1. ASHRAE Standard 15
   2. ASHRAE Standard 62.1

1.3 SUBMITTALS

A. Product Data
   1. Equipment cut-sheets on all control panels, sensors, audio and visual alarms and system accessories.
   2. Installation instructions including manufacturer's recommended mounting heights and locations for all sensors.
   3. Wiring diagrams for the complete system. Include the interface points for the building automation system, ventilation equipment and emergency shut down of equipment.

1.4 QUALITY ASSURANCE

A. Product Support: Supplier shall have organization, located within 150 miles of site, with capability of complete on-site product support.

PART 2 - PRODUCTS

2.1 DETECTION SYSTEMS

A. Areas Served and Gases Detected
   1. Maintenance Garage – Carbon Monoxide and Nitrogen Dioxide

B. Acceptable Manufacturers
   1. Honeywell
   2. PureAire
   3. Toxalert
   4. Thermalgas
   5. Vulcain
   6. Genesis International Inc
   7. Armstrong Monitoring

C. General
   1. All system components shall be provided by a common manufacturer.

D. Control Panel
   1. Locate the control panel as indicated on the drawings.
   2. Automatic microprocessor-based industrial-class system that monitors the concentration levels of the required gases in the spaces monitored.
   3. The system shall include displays of the concentration levels of the gases detected by each sensor and provide audible and visual alarms when these gases are detected.
   4. Control/transmitter panels with displays and user control functions shall be located at least 42 inches above the finished room floor.
   5. System shall be capable of indicating, alarming, shutting down equipment, and automation / ventilation interface. Where combustion equipment is employed, monitoring system shall automatically shut down the combustion equipment in event of refrigerant leakage or if combustible gas is detected if other acceptable conditions are not specified.
   6. Capability to remotely mount sensor from transmitter to allow calibration at convenient point up to 100 feet away.
   7. Sensor/transmitter display shall indicate all diagnostic check/fault conditions with detailed message displays.
   8. Full-function keypad or magnetic touch points to allow setting alarm set points, change span gas values and display date of last calibration.
   9. Pilot lights or LEDs (light emitting diodes) shall indicate:
      a. Unit normal operation /NOT in alarm
      b. High limit / unit in alarm
      c. Indicate unit malfunction
   10. Carbon Monoxide detector panel shall have an on-board audible device to generate an output of 85 dBA at 10 ft from the panel.
   11. All remote sensor shall be powered by low voltage from permanent building wiring, units are to be provided with transformer to supply low voltage power.

E. Building Automation System Interface
   1. Interface to the building automation system to relay alarm conditions shall be via dry contacts in the control panel.
   2. The control panel shall be capable of providing direct digital and / or analog signals to the building automation system to relay contaminant concentrations to allow for monitoring / trending / activation of ventilation equipment.

F. Power Supply
   1. Unit control panel to be served by a 120 / 1, 20 A circuit.
   2. Panel to have battery back up to protect system from surges, spikes, transients, overloads in the incoming power supply.
   3. Battery backup power shall be provided to the carbon monoxide detection system. Battery backup shall have visible and audible alarms to identify lower battery power.

G. Remote Visual and Audible Alarms
   1. Carbon Monoxide detection system shall include remote combination horn/strobes mounted inside the room with fuel-fired equipment. Combination horn/strobes shall generate an audible alarm at 85dBA at 10 feet. Visual detection shall generate 189 lumens at 65 fpm with a blue lens cover over the light.

## 2.2 MAINTENANCE GARAGE SYSTEM

A. Gases Detected
   1. Carbon Monoxide
   2. Nitrogen Dioxide

B. System Alarm
   1. Warning Level (Stage 1):
   2. When a concentration level outside of the normal operating levels occurs, the control panel shall do the following:
   3. Activate the room emergency ventilation system
   4. Provide a warning level signal to the control panel
   5. Provide a warning level signal to the building automation system
   6. Alarm Level (Stage 2):
   7. On a prolonged presence of a chemical concentration outside the normal operating levels the control panel shall do the following:
   8. Activate the control panel audible and visual alarm
   9. Provide an alarm level signal to the building automation system

C. Sensor Locations
   1. Provide sensors as needed to provide total room coverage.
   2. Position sensors at the proper elevation to measure the specific gas to be detected.

D. Sensor Description
   1. Carbon Monoxide Sensor
   2. Provide a remote carbon monoxide (CO) sensor(s) as located on the drawings.

3. The remote CO sensor shall utilize a solid state sensing element, be microprocessor based and be both temperature and humidity compensated for long life and stability.
4. In the unit malfunction condition the CO sensors output shall be fail-safe and indicate steady high CO condition.
5. The CO sensor range shall be 0 to 250 ppm.
6. Set point 25 – 50 ppm.
7. Nitrogen Dioxide Sensor
8. Provide a remote nitrogen dioxide ($NO_2$) sensor(s) as located on the drawings.
9. The remote $NO_2$ sensor shall utilize an electro-chemical element and have range of 0-10 ppm.
10. The sensor shall be housed in an impact-resistant, non-flammable, IP66 rated housing.
11. The sensor response time shall reach 90% of level being sensed within 30 seconds.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Start-up and Commissioning
   1. Utilize a factory-authorized service representative to perform the following:
      a. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
      b. Test alarm set points of the monitoring system(s) with calibration gases and verify sequence of operation.
      c. Prepare a written report to record test procedures, test results and corrective actions if required.
      d. Report should also cover the requirements for accessories like adequacy of alarm types, signs and protective equipment.

B. Demonstration and Training
   1. Utilize a factory-authorized service representative to train owner's maintenance personnel to adjust, operate, diagnose, calibrate and maintain the refrigerant monitoring system.

C. Calibration
   1. Sensor/transmitters shall be calibrated with hand-held calibration devices furnished by system manufacturer.
   2. Provide complete calibration kit, including test gases, for commissioning and future calibrations. Provide permanently mounted hose for remote-mounted sensors.

D. Install all equipment per manufacturer's requirements.

**END OF SECTION**

**SECTION 231000**

**FACILITY FUEL SYSTEMS**

PART 1 - GENERAL

1.1 SCOPE

A. Provide complete fuel storage and distribution system consisting of: underground fuel storage tank, fuel piping, monitoring system, transfer pump package, day tank package, accessories, and fuel for testing.

1.2 REFERENCES

A. NFPA 30 - Flammable and Combustible Liquids Code

B. Underwriter's Laboratories (UL)

C. ETL Testing Laboratories (ETL)

D. Steel Tank Institute (STI)

E. Factory Mutual Engineering and Research (FM)

1.3 SUBMITTALS

A. Submittals Package: Submit the Product Data, and Quality Control Submittals specified below at the same time.

B. Product Data: Catalog sheets, specifications, illustrations, wiring diagrams and installation instructions for each item specified for each type of system.

C. Quality Control Submittals:
   1. Tank Installation Contractor's Qualifications Data:
      a. Name of Contractor, business address and telephone number.
      b. Names and addresses of 3 similar projects that the Contractor has worked on during the past 5 years.
      c. Copy of certification from tank manufacturer or state license.
   2. Pipe Installer's Qualifications Data:
      a. Name of person who will be performing or directly supervising the work and their employer's name, business address and telephone number.
      b. Names and addresses of 3 similar projects that this person has worked on during the past 5 years.
      c. Copy of certification from pipe manufacturer.
   3. Factory Test Certificate: For each fuel storage tank.

4. Final test procedure documentation.

D. Contract Closeout Submittals:
1. Operation and Maintenance Data: Two copies, covering the installed products.
2. Warranty: Copy of all warranties.
3. Tank Manufacturer Installation Check List: Two completed copies.
4. Two copies of all approved permits and applications filed for system installation.

## 1.4 QUALITY ASSURANCE

A. Qualifications:
1. Tank Installation Contractor:
a. The firm performing the work of this Section shall have been regularly engaged in the installation and maintenance of underground fuel storage tanks for a minimum of 5 years, and shall have completed 3 similar projects.
b. The firm shall be certified by the tank manufacturer or licensed by the Iowa Department of Natural Resources as a Certified Underground Storage Tank (UST) Installer.
2. Pipe Installer: Individual with minimum 5 years experience in installing underground fuel piping, have worked 3 similar projects, and shall be certified by pipe manufacturer of the type of pipe being installed.

B. Listings: All components of the system for which Underwriters' Laboratories, Inc. (UL) provides product listing service, shall be listed and bear the listing mark.

C. Regulatory Requirements:
1. Systems shall comply with the applicable requirements of UL 58, NFPA 30, NFPA 31, Iowa Administrative Code Section 567-Chapter 135.
2. Systems shall comply with all Iowa Department of Natural Resources requirements.
3. Contractor shall apply and pay for all associated fees required to install the complete fuel system.

## 1.5 WARRANTY

A. Steel Tanks: Thirty year Steel Tank Institute warranty for each tank for internal and external corrosion.

B. Composite Tanks: Thirty year manufacturer's warranty for each tank for internal and external corrosion.

C. Fiberglass Tanks: Thirty year manufacturer's warranty for each tank.

D. All other components shall have a minimum one year manufacturer's warranty.

## 1.6 MAINTENANCE

A. Spare Parts:
1. Two keys for each padlock.

B. Special Tools:
1. One stick gage and two calibration charts for each fuel tank.
2. Two tools for each type and size vandal resistant fastener.
3. Two lifting arms for composite type manhole frames and lids.

## PART 2 - PRODUCTS

### 2.1 DOUBLE WALL STEEL TANK – ABOVEGROUND

A. Features:
1. Double wall steel aboveground storage tank with a primary (internal) steel tank completely surrounded (full 360 degrees, 100 percent of Volume) by a secondary (external) steel tank.
2. Interstitial space between the primary and secondary tank walls to allow for the free flow and containment of all leaked product from the primary tank, and the insertion of a monitoring device through a 2-1/2 inch tube which extends vertically to the top of the tank from a small sump at the bottom of the tank.
    a. Deliver tanks to the work site with interstitial space filled with a vacuum to protect tank from condensation and corrosion.

B. Design Criteria: Steel Tank Institute (STI) approved, UL labeled for above ground service in accordance with UL-142 Construction Standard for Aboveground Tanks, and UL-1746 for External Corrosion Protection.

C. Construction:
1. Materials: Carbon steel.
2. Factory Pressure Test: Test before installing secondary tank; prove tight under test pressures recommended by tank manufacturer.
3. Surface Preparation: Sandblast the entire surface of the tank to a SSPC-6 commercial finish.
4. Factory Applied Protective Coating for Outer Tank:
    a. Clad with 125 mil minimum dry film thickness of isophthalic resin with chopped strand glass fibers.
    b. Complete integrity of the cladding system is assured by a 10,000 volt minimum spark test performed over the entire surface at the manufacturer’s plant.
5. Electric Isolation: Nylon dielectric bushings.
6. Cathodic Protection System: Zinc sacrificial anodes complete with monitoring system.

D. Monitor and Fill Fittings: 4 inch NPT fitting.

E. Tank Hold-Down Devices:

1. Hold-Down Strap (By Tank Manufacturer):

    a. Polyester Straps: Two ply, 9800 lb polyester webbing fabricated with twisted eye reinforced loop on both ends for connecting to concrete anchors.
        1) Strap width dependent on tank diameter and as recommended by tank manufacturer.Steel Straps: Preshaped to tank contour; each strap

terminating with a cadmium plated ASTM A 36 steel threaded adjustment rod and turnbuckle on both ends.

1) Protective Coating: Factory coated with black coal tar epoxy.

2. Anchor Bolts: Cadmium plated ASTM A 36 steel or Type 304 stainless steel (ASTM A 276), same diameter as the strap end rods and threaded on both ends; one end to fit the turnbuckle and the other end fitted with a 1/4 x 4 inch square steel plate, structural nut and washer. Length as required for proper anchoring. Custom fabricate cadmium plated steel anchor bolts to allow for cadmium plating.

F. Tank Identification: Permanent stencils, labels, or plates mounted on tanks and at fill ports; and which include the following information:
1. Name of tank manufacturer.
2. Date of tank installation (Fill port only).
3. Year in which tank was manufactured.
4. Unique identification number.
5. Dimensions, design, working capacity, and tank model number.
6. Manufacturer's statement that tank conforms with all regulatory requirements.
7. Standard of design by which tank was manufactured.
8. List of products and additives which may be permanently stored in tank.

## 2.2 TANK FILL ASSEMBLY

A. Top Seal Fill Pipe Cap: Model # 634-TT

B. Top Seal Fill Pipe Swivel Adapter: Model # 61SALP-1020-EVR

## 2.3 NAMEPLATES

A. Construction: Minimum 1/8 inch thick two color laminated plastic engravers stock with the following items engraved in contrasting symbol and background colors conforming to the American Petroleum Institute (API) color coding for the particular fuel type, and consistent with facility fuel supplier's marking.
1. API color symbol.
2. Fuel type identification in words.
3. Tank manufacturer.
4. Tank type.
5. Tank diameter and capacity.
6. Tank identification number.
7. Installation date or date of manufacture.
8. Installers name.
9. Nameplate Holders: Corrosion resistant steel plates and straps (4 inch) with vandal resistant fasteners; Model # 107.

## 2.4 PADLOCK

A. Provide one lock for each fill cap. Bronze, Master Lock Model # 911-DKA. Key all locks alike.

2.5 STICK GAGE

A. Hardwood, calibrated in 1/8 inch increments.

2.6 FUEL OIL ACCESSORIES PACKAGE

A. Vents (No. 2 Fuel Oil and Diesel Fuel Tanks): Atmospheric, aluminum body and cover, open type 40 mesh brass screen. Model # 23.

B. Pipe Cap: Die cast zinc, steel cross bar, (4 inch), Model #116.

C. Foot Valve: Double poppet type with bronze body and poppet, metal to metal seat, 8-mesh galvanized brass screen, and extension legs; Model # 86 or 92.

D. Extractor Fitting: Cadmium plated cast iron body with bronze cap and chromed tanned leather gasket; Model # 233.

E. Ball Float Vent Valve: Stainless steel ball float; Model # 53VML.

F. Locking Pipe Cap: Composite plastic with lockable toggle closure and Buna-N gasket; Model # 634TT.

G. Drop Tubes: Model # 61T.

2.7 TANK GAGING, LEAK AND OVERFILL MONITOR SYSTEM

A. Acceptable Manufacturers
   1. Veeder Root
   2. OPW

B. Type: Continuous automatic operation tank gaging, leak detection and overfill monitor system for double wall storage tanks, double wall product piping, and containment sumps.
   1. Systems shall have system test capability, and shall be UL listed.

C. Alarm/Monitor Panels: Locate panel as shown on drawings.
   1. The panel shall visually indicate the following:
      a. Status of each tank's interstitial space (dry, water, or hydrocarbon condition).
      b. Status of each containment system (dry, water, or hydrocarbon condition).
      c. Status of high level sensor set at 95 percent of tank operating capacity (on or off). When sensor is tripped, audio alarm shall be activated and be audible at fill port location.
   2. Panel to include:
      a. Audible and visual alarm
      b. Digital display screen
      c. Integral printer
      d. Ethernet/IP communications interface to Owner's Building Automation System (BAS).

D. Leak Sensors:
   1. Detects fuel presence, high level, or low level conditions in the following:
      a. Interstitial space between tank walls.
      b. Buried double-wall piping.
      c. Containment and overfill sumps.
   2. Sensors: 0.1 GPH, non-distinguishing type not sensitive to condensation forming on the sensor surface, or dripping across the sensor surface.

E. Instrumentation Control Cable: Connect probe and sensor to alarm monitor panel, as recommended by manufacturer of leak and overfill monitor system.

## 2.8 FUEL PIPING AND VALVES

A. Steel Piping:
   1. Steel Pipe for Threading: Standard weight, Schedule 40, black; ASTM A 53 or ASTM A 135.
   2. Malleable Iron, Steam Pattern Threaded Fittings: 150 lb Class: ASME B16.3.
   3. Unions: Malleable iron, 250 lb class, brass to iron or brass to brass seats.
   4. Couplings: Same material and pressure rating as adjoining pipe, conforming to standards for fittings in such pipe. Use taper tapped threaded type in screwed pipe systems operating in excess of 15 psig.
   5. Nipples: Same material and strength as adjoining pipe, except nipples having a length of less than one inch between threads shall be extra heavy.
   6. Thread Sealant: Fuel resistant Joint Seal by EMCO Wheaton.

B. Polyethylene Piping
   1. Piping: High density double-wall polyethylene piping. PVDF inner, outer barriers, and jacket. OPW Flexworks C Series
   2. Fittings: Stainless steel swivel swage fittings with integral spill monitoring ports. OPW DPC Series.
   3. Fittings, Seals, and Joining Materials shall be same as piping manufacturer.

C. Reinforced Thermosetting Resin Piping (RTRP):
   1. Conform with ASTM D 2310, Classification RTRP-11; and ASTM D 2996, Classification RTRP-11.
   2. Fittings and Joining Materials: Comply with the RTRP Manufacturer's recommendations for the intended service.

D. Access Piping:
   1. Piping: Corrugated polyethylene piping to encase buried double-wall fuel piping. Complying with DOT H-20 load requirements. OPW Flexworks AXP40.
   2. Piping shall be continuous with no joints from containment sump to inside building.

E. Valves:
   1. Acceptable Manufacturers: Conbraco, Hammond, Milwaukee, Nibco, and Watts.
   2. Gate (GV-1): 125 psig WSP, 200 psig WOG, bronze body, union bonnet, solid wedge disc, and threaded ends.
   3. Gate (GV-2): 125 psig WSP, 200 psig WOG up to 12 inch size; IBBM OS&Y, bolted bonnet, solid wedge disc, and threaded or flanged ends depending on size.

4. Check (CK-1): 125 psig WSP, 200 psig WOG, bronze body, brass or bronze trim, horizontal swing, renewable and regrindable disc, and threaded ends.
5. Check (CK-2): 125 psig WSP, 200 psig WOG, IBBM, horizontal swing, bolted bonnet, regrindable and renewable seat ring and disc, and threaded or flanged ends depending on size.
6. Ball (BV-1): 2000 psig non-shock cold working pressure, WOG, one piece carbon steel body, solid blow-out proof stem, PTFE seats and seals, stainless steel trim, corrosion resistant steel lever handle with vinyl grips, and threaded ends.

F. Flexible Entry Boots:
1. Type: Flexible construction with stainless steel hose clamps, and sized to match access pipe diameter. Watertight with internal and external seals. OPW Flexworks DEB Series.

G. Flexible Connections
1. Flexible Piping (underground within containment sump): 322 Stainless steel hose with braided type 304 stainless steel outer jacket. Schedule 80 stainless steel fittings with two seals Viton/Buna-N, one threaded end and one threaded swivel end. 150 psi maximum working pressure. OPW Commando.

## 2.9 FUEL FOR TESTING

A. Contractor to provide one full tank of fuel. Coordinate with the Owner for the delivery of a full tank of fuel for testing to verify that fuel transfer equipment and instrumentation is operating properly.

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Testing Prior to Installation:
1. Before placing the tank into its excavation, plug all openings and pressure test tank in accordance with manufacturer’s printed test instructions, unless otherwise specified.
2. Tanks should not be pressurized beyond manufacturer’s specified limits. The tank must hold the test pressure for 30 minutes.
3. Check fitting connections, and seams in outermost tank by applying a soap suds solution.
4. Reject any leaking tanks.

## 3.2 INSTALLATION

A. Install the Work of this section in accordance with the item manufacturer’s printed installation instructions, unless otherwise shown or specified.

## 3.3 TANK ACCESSORIES

A. Fuel Identification: Attach laminated plastic nameplate to each tank fill pipe to identify the fuel in the tank.

B. Tank Identification: Affix tank identification stencil, label, or plate permanently to tanks and fill ports.

C. Install padlocks on all lockable caps on fill piping.

D. Terminate vent lines with vent caps.

E. Overfill Alarm Device Sign: Mount sign adjacent to alarm device in a location that is easily readable from ground level.

F. Cathodic Protection Monitoring Station For Double Wall Steel Tanks: Provide monitoring connections at grade.

## 3.4 FUEL PIPING

A. Pitch horizontal underground piping upward from the containment sump 1/8 inch per foot minimum. Pitch horizontal above ground piping upward from tank 1/8 inch per foot minimum.

B. Install all piping per manufacturer's instructions.

C. Seal all penetrations through building floors or walls per Section 221100.

D. Pipe and Fitting Schedule:
   1. Fuel Supply Piping:
      a. Underground: Double wall flexible primary piping within access pipe, with fittings, joining methods, and materials as recommended by flexible primary piping and access pipe manufacturer.
      b. Above Ground: Standard weight black steel pipe, with screwed end 150 lb malleable iron fittings, with fuel resistant thread sealant.

   2. Interstitial Leak Monitor Riser Piping:
      a. Standard weight black steel pipe, with screwed end 150 lb malleable iron fittings, with fuel resistant thread sealant. Coat piping with corrosion protective tape primer, and wrap with corrosion protective tape.

B. Valve Schedule:

| SERVICE | SYMBOL | PRESSURE CLASS | SIZE | VALVES |
|---|---|---|---|---|
| Fuel Supply | GASOLINE, DIESEL | 125 psi and Less | 2" and Less | BV-1, GV-1, CK-1 |
| | | | 2-1/2" and Up | GV-2, CK-2 |

## 3.5 FIELD QUALITY CONTROL

A. Testing: After installation of tank and piping, test the system in the presence of the Owner and/or Engineer, as follows:

1. Piping: Before painting or backfilling, plug ends and test with air at manufacturer's recommended test pressure, and hold for 5 hours without leaking.
2. Tanks:
   a. Before backfilling, pressure test tank in accordance with manufacturer's printed test instructions, unless otherwise specified.
   b. Tanks should not be pressurized beyond manufacturer's specified limits.
   c. The tank must hold the test pressure for 30 minutes.
   d. Check fitting connections, and seams in outermost tank by applying a soap suds solution.
   e. After backfilling, make measurement of vertical distance from top of 4 inch gage opening to top of impact/deflector plate, and submit this information to the Owner and Engineer.
3. Fuel System Demonstration:
   a. After reconnecting piping, burning apparatus, and tanks, and when directed, perform a system acceptance test in the presence of the Owner and/or Engineer to demonstrate that the fuel system is operating properly.
   b. Demonstrate that all controls, pumps, alarms, safeties and communication interfaces operate properly.
   c. Make required repairs and final adjustments.

**END OF SECTION**

**SECTION 231126**

**NATURAL GAS PIPING**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Natural gas Piping System indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
   1. Piping
   2. Regulators
   3. Unions
   4. Valves

1.2 REFERENCES

A. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
   1. Adopted version of the International Fuel Gas Code.
   2. Adopted version of NFPA 54, National Fuel Gas Code.
   3. ASME as it pertains to the welding of piping.
   4. State Boiler Code

1.3 SUBMITTALS

A. Product Data
   1. Catalog sheets and specifications indicating manufacturer name, type, applicable reference standard, schedule, or class for specified pipe and fittings.
   2. Material Schedule: Itemize pipe and fitting materials for each specified application in Pipe and Fittings Schedule in Part 3 of this Section. Where optional materials are specified indicate option selected.

B. Submit piping layout drawings as per Section 230500.

1.4 QUALITY ASSURANCE

A. All materials, equipment and Work shall meet or exceed all applicable federal, state and local requirements and conform to codes and ordinances of authorities having jurisdiction.

B. Valves: Manufacturer's name, size, standards compliance and pressure rating clearly marked on outside of valve body.

C. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.

D. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

E. Installer Qualifications: Company specializing in performing the Work of this Section with minimum three (3) years documented experience. All installation shall be supervised by a licensed Master Plumber. All testing shall be performed by a licensed Journeyman or Master Plumber. Welders shall be certified in accordance with ASME.

## 1.5 EXTRA MATERIALS

A. Provide one (1) plug valve wrench for every ten (10) plug valves sized 2 inches and smaller, minimum of one (1). Provide each plug valve sized 2-1/2 inches and larger with a wrench incorporating a setscrew.

# PART 2 - PRODUCTS

## 2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Natural gas pressures shall not exceed two (2) pounds per square inch gauge on customer side of the meter.

C. Pipe joint compound shall be lead-free, non-toxic, non-hardening, insoluble in the presence of natural gas and compliant with ANSI/NSF 61 and Federal Specification TT-S-1732. Temperature service range of -15° F to +400° F.

## 2.2 PIPING

A. Steel Piping

B. Schedule 40 black steel, ASTM A53, Grade A or B, seamless or electric resistance welded.

C. Malleable Iron, Steam Pattern Threaded Fittings
   1. 150 lb Class: ASME B16.3

D. Schedule 40 Carbon Steel Fittings

E. ASME B16.9

2.3 EXCEPTIONS

A. All piping distributed within the building and above 5 psi is required to be welded.

B. Gas piping is prohibited from being installed in solid partitions or walls unless a chase or casing (pipe sleeve) is provided.

C. Threaded fittings shall not be used for pipe sizes 4 inches and larger.

2.4 VALVES

A. Acceptable Manufacturers:

B. A.Y. McDonald

C. Homestead

D. Nibco

E. Milwaukee

F. Nordstrom

G. Mueller.

H. All valves shall be designed, manufactured and approved for natural gas service.

I. Line Shut-off Valves sizes 2” and smaller:

J. Iron body lubricated plug valve conforming to ASME B16.33, U.L. Listed, and A.G.A. Approved for natural gas service with threaded ends, wrench operation, rated for 175 WOG service pressure and –20 to 150° F.

K. Brass body, full port ball valve conforming to ASME B16.44 and U.L. Listed. Blowout-proof stem and PTFE seats. Approved for natural gas service not to exceed 5 psig with threaded ends, rated for 600 WOG, 150 PSI WSP and 32 to 125°F working temperature.

L. Line Shut-off Valves sizes 2 1/2” and larger:

M. Iron body lubricated plug valve conforming to ASME B16.38, U.L. Listed, and A.G.A. Approved for natural gas service with flanged ends, wrench operation, rated for 125 WOG service pressure and –20 to 150° F.

N. Brass body, full port ball valve conforming to ASME B16.44 and U.L. Listed. Blowout-proof stem and PTFE seats. Approved for natural gas service not to exceed 5 psig with threaded ends, rated for 600 WOG, 150 PSI WSP and 32 to 125°F working temperature.

O. Appliance/Equipment Shut-off Valves at local connections sizes two (2) inches and smaller shall be bronze body, full port ball or butterfly type, U.L. Listed, and A.G.A. Approved for natural gas service with threaded ends, quarter turn lever handle operation, rated for 175 W.O.G. service pressure and 30 to 275° F.

P. Manual Emergency Shut-off Valves 2" and smaller shall be bronze body, full port ball or butterfly type, U.L. Listed, and A.G.A. Approved for natural gas service with threaded ends, quarter turn lever handle operation, rated for 175 W.O.G. service pressure and 30 to 275° F.

Q. Automatic Emergency Shut-off Valves shall be U.L. Listed for natural gas service, two (2)-way electrically tripped solenoid type; fail safe closed; manual reset; Type 1 solenoid enclosure; NBR seals and disc; stainless steel core tube and springs; copper coil.

## 2.5 PRESSURE REGULATORS

A. Acceptable Manufacturers:

B. Fisher

C. Maxitrol

D. Rockwell

E. Schlumberger.

F. All pressure regulators shall be designed, manufactured and approved for natural gas service.

G. Pressure regulators for individual service lines shall be capable of reducing distribution line pressure to pressures required for equipment. Pressure relief shall be set at a lower pressure than would cause unsafe operation of any connected unit. Regulator shall have a single port with orifice diameter no greater than that recommended by manufacturer for the maximum gas pressure at the regulator inlet. Regulator vent valve shall be of resilient materials designed to withstand flow conditions when pressed against valve port. Regulator shall be capable of limiting build-up of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Commercial grade diaphragm type with internal relief valve, vent valve, cast iron body, Buna-N diaphragm.

H. Install pressure gauge adjacent to and downstream of each line pressure regulator.

## 2.6 UNIONS

A. Unions in 2" and smaller in ferrous lines shall be Class 300 AAR malleable iron unions with iron to brass seats, 2-1/2" and larger shall be ground flange unions. Companion flanges on lines at various items of equipment, machines and pieces of apparatus may serve as unions to permit disconnection of piping.

B. Unions connecting ferrous pipe to copper or brass pipe shall be Epco dielectric type.

C. Above grade flexible stainless steel appliance/equipment connectors shall conform with AGA under the ANSI Z21.69 Standard. Hose shall be braided stainless steel with a polyolefin heat-shrink tubing with high flame-retardant qualities. Hose shall be equipped with malleable iron unions and spring loaded brass quick-link couplings. An easily accessible manual shut-off valve shall be installed ahead of all hose connections. Specify T&S Brass "Safe-T-Link" or approved equal.

## 2.7 FLANGES

A. All 150 lb. and 300 lb. ANSI flanges shall be domestically manufactured, weld neck forged carbon steel, conforming to ANSI B16.5 and ASTM A-181 Grade I or II or A-105-71. Slip on flanges shall not be used.

B. Each fitting shall be stamped as specified by ANSI B16.9 and, in addition, shall have the laboratory control number stenciled on each fitting for ready reference as to physical properties and chemical composition of the material. Complete test reports may be required for any fitting selected at random.

C. Flanges which have been machined, remarked, painted or otherwise produced domestically from imported forges will not be acceptable. Flanges shall have the manufacturer’s trademark permanently identified in accordance with MSS SP-25.

D. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. Threaded rods will not be an acceptable alternate for flange bolts. Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi.

E. Flat-faced flanges shall be required to match flanges on pumps, check valves, strainers, etc. Only one (1) manufacturer of weld flanges will be approved for each project.

F. All flanges shall be gasketed. Contractor shall place gasket between flanges of flanged joints. Gaskets shall fit within the bolt circle on raised face flanges and shall be full face on flat face flanges. Gaskets shall be cut from 1/16” thick, non metallic, non asbestos gasket material suitable for operating temperatures from -150° F to +75° F.

# PART 3 - EXECUTION

## 3.1 DELIVERY, STORAGE AND HANDLING

A. Accept piping, fittings, and accessories on Site in shipping containers with labeling in place, inspect for damage and store with a minimum of handling. Store plastic piping under cover out of direct sunlight. Do not store materials directly on the ground.

B. Provide temporary protective coating on all cast iron and steel devices.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work and isolating parts of completed system.

## 3.2 PREPARATION

A. Ream pipe ends and remove cutting burrs. Bevel plain end ferrous pipe.

B. Remove cutting oil, scale and dirt, on inside and outside of piping, before assembly.

## 3.3 PAINTING

A. Prepare all piping as needed to allow for proper coverage and adherence.

B. Piping to be painted includes the following:
   1. Exterior to building: Color selected by Architect.
   2. Interior to building: Yellow
   3. Extension of existing system: Match existing color

## 3.4 EQUIPMENT CONNECTIONS

A. Provide specified connections, shutoff valves, regulators and unions at each and every appliance and piece of equipment requiring natural gas, including equipment furnished under other Divisions of these Specifications and/or by the Owner.

B. Provide and install union type connections at all equipment to permit removal of service piping.

C. Gas service connections shall have a diameter at least one (1) pipe size larger than that of the inlet connection to the equipment as provided by the manufacturer and be of adequate size to provide the total input demand of the connected equipment.

D. Provide listed and labeled appliance connectors complying with ANSI Z21.69 and listed for use with food service equipment having casters, or that is otherwise subject to movement for cleaning, and other large movable equipment. Connectors shall have listed and labeled quick-disconnect devices and shall have retaining cables attached to structures and equipment. Connectors shall not be concealed within or extended through wall, floor or partition and shall be located entirely in the same room as the connected equipment. Provide an accessible shut-off valve not less than the nominal size of the equipment connector, immediately ahead of the connector.

E. Rigid metallic pipe and fittings shall be used at service connections to all permanently stationary equipment.

## 3.5 INSTALLATION - GENERAL

A. All gas piping installed in return air plenums shall be welded.

B. Valves shall not be installed in concealed locations and return air plenums.

C. Line shutoff valves installed exterior to the building shall be lubricated plug valves. Line shutoff valves installed interior to the building shall be full-port ball valves.

D. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

E. All installation shall be in accordance with manufacturer's published recommendations.

F. Provide support for and connections to natural gas service meter in accordance with requirements of the utility company.

G. All installation shall be in accordance with manufacturer's published recommendations.

H. All above ground gas piping shall be electrically continuous and bonded to electrical system ground conductor in accordance with NFPA 70.

I. Provide and install unions at proper points to permit dismantling or removal of pipe. No unions will be required in welded lines except at equipment connections.

J. Provide dielectric isolation device where copper lines connect to ferrous lines or equipment, such as dielectric union, coupling or dielectric flange fitting.

K. Valves, regulators, flanges, unions and similar appurtenances shall be accessible for operation and servicing and shall not be located above ceilings in accessible locations or within partitions.

L. Route piping in orderly manner and maintain gradient. Install piping to conserve building space. Group piping whenever practical at common elevations.

M. Install piping to allow for expansion and Contraction without stressing pipe, joints, or connected equipment.

N. Make service connections at the top of the main, whenever the depth of the main is sufficient to allow top connections. When service connections cannot be made at the top of the main, they shall be made on the side of the main no lower than the horizontal midpoint of the gas main.

O. Cross type fittings shall not be installed in any gas line. Bushings shall not be used in conjunction with any gas piping.

P. Slope piping and arrange to drain at low points. Install drip/sediment traps at points where condensate and debris may collect. Locate drip/sediment traps where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing. Construct drip/sediment traps using tee fitting with capped nipple connected to bottom outlet. Use minimum-length nipple of three (3) pipe diameters, but not less than 4 inches long, and same size as connected pipe. Cap shall be screwed pattern, black, standard weight, malleable iron. Install with adequate space for removal of cap.

Q. Install valves for shut off and to isolate equipment, parts of systems, or vertical risers. All valves shall be located such that servicing and operation is possible. All flanged valves shown in horizontal lines with the valve stem shall be positioned so that the valve stem is inclined one bolt hole above the horizontal position. Screw pattern valves placed in horizontal lines shall be installed with their valve stems inclined at an angle of a minimum of 30 degrees above the horizontal position. All valves must be true and straight at the time the system is tested and inspected for final acceptance. Valves shall be installed as nearly as possible to the locations indicated in the Contract Drawings. Any change in valve location must be so indicated on the Record Drawings.

R. Install line shut-off valve at each branch connection to riser. Branch line shut-off valves shall be automatic type where indicated on Drawings.

S. Provide adequate clearance for access to and operation of all valves.

T. Install valves with stems upright or horizontal, not inverted unless required otherwise by the valve manufacturer.

U. Pipe vents from gas pressure reducing valves and pipe casing sleeves to the exterior of the building and terminated with outlet turned down and capped with corrosion resistant insect screen. Vent terminations shall be at least seven feet above grade or pedestrian traffic and a minimum five (5) feet above or twenty five (25) feet horizontally from all air intakes or building openings.

V. Above ground horizontal natural gas and encasement piping shall be supported at intervals of no greater than 6 foot for 1/2" piping, 8 foot for 3/4" and 1” piping and 10 foot for 1-1/4” and larger piping. Vertical piping shall be supported at each floor level and at intervals as specified for horizontal piping.

W. Extension bars shall not be used for supporting gas or encasement piping. Gas or encasement piping shall not be used to support any other piping or component.

## 3.6 INSTALLATION - WELDED PIPING

A. Welding of pipe in normally occupied buildings is prohibited. Off-Site welding is acceptable. Should welding be required in a normally occupied building for connecting to an existing welded system, obtain written approval from the Construction Manager and comply with Owner’s fire and life safety requirements.

B. Piping and fittings shall be welded and fabricated in accordance with ASME/ANSI.

C. Ensure complete penetration of deposited metal with base metal. Provide filler metal suitable for use with base metal. Maintain inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc or gas welding process. All pipes shall have the ends beveled 37 1/2 degrees and all joints shall be aligned true before welding. Except as specified otherwise, all changes in direction, intersection of lines, reduction in pipe size and the like shall be made with factory-fabricated

welding fittings. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction will not be permitted.

D. Align piping and equipment so that no part is offset more than 1/16". Set all fittings and joints square and true and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.

E. Contractor shall not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welded during welding operation.

F. In no cases shall Schedule 40 pipe be welded with less than three (3) passes including one (1) stringer/root, one (1) filler and one (1) lacer. Schedule 80 pipe shall be welded with not less than four (4) passes including one (1) stringer/root, two (2) filler and one (1) lacer. In all cases, however, the weld must be filled before the cap weld is added.

## 3.7 WELD TESTING

A. All welds are subject to inspection, visual and/or x-ray, for compliance with Specifications. At the Owner's option, the Owner will provide employees or employ a testing laboratory for the purposes of performing said inspections and/or x-ray testing. Initial visual and x-ray inspections will be provided by the Owner. The Contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and retesting of any welds found to be unacceptable. In addition, the Contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.1 and B31.3 due to the discovery of poor, unacceptable or rejected welds.

B. Welds lacking penetration, containing excessive porosity or cracks, or are found to be unacceptable for any reason, must be removed and replaced with an original quality weld as specified herein. All qualifying tests, welding and stress relieving procedures shall, moreover, be in accord with Standard Qualification for Welding Procedures, Welders and Welding Operators, Appendix A, Section 6 of the Code, current edition.

## 3.8 TESTING

A. All natural gas systems shall be inspected, tested, purged and placed into operation in accordance with NFPA 54 and as required herein.

B. All natural gas piping systems shall be very carefully inspected, tested, purged and placed into operation by a Licensed Plumber.

C. All necessary apparatus for conducting tests shall be furnished by the Contractor and comply with the requirements of NFPA 54.

D. All new rough-in distribution piping and affected portions of existing systems connected to, shall be subjected to a pneumatic test pressure utilizing clean, dry air and must be demonstrated to be absolutely tight when subjected to the pressures and time durations listed herein. All

equipment and components designed for operating pressures of less than the test pressure shall not be connected to the piping system during test.

E. Systems on which the normal operating pressure is less than 0.5 pounds per square inch gauge (psig), the test pressure shall be 5.0 psig and the time interval shall be thirty (30) minutes.

F. Systems on which the normal operating pressure is between 0.5 psig and 5.0 psig, the test pressure shall be 1.5 times the normal operating pressure or 5.0 psig, whichever is greater, and the time interval shall be thirty (30) minutes.

G. Systems on which the normal operating pressure is 5.0 psig or greater, the test pressure shall be 1.5 times the normal operating pressure, and the time interval shall be one (1) hour.

H. After testing is complete, the entire gas system shall be purged with dry nitrogen to eliminate all air, debris and moisture from the piping before natural gas is introduced into the system.

I. After successful results of pressure test and purging have been completed, a leakage test shall be performed in accordance with NFPA 54 Appendix D.

J. Connect, inspect and purge gas utilization equipment, lab hook-ups, outlets, etc., and place into operation only after successful results of pressure test, leakage test and purging have been completed and accepted.

K. In all instances in which leaks are then found, they shall be eliminated. Testing operations shall be repeated until gas-piping systems are absolutely tight at the pneumatic test pressures indicated above.

L. Pressure test gas piping sleeve system with clean, dry compressed air at 15 psig by temporarily sealing all openings between gas carrier pipe and sleeve and vent openings. Sleeve systems must be demonstrated to be absolutely tight when subjected to this pressure for a period of four (4) hours.

**END OF SECTION**

**SECTION 232300**

**REFRIGERANT PIPING**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all work required to provide and install the Refrigerant Piping indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
   1. Piping
   2. Equipment
   3. Valves
   4. Accessories
   5. Specialties

1.2 REFERENCES

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.3 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. Refrigerant piping indicated on Drawings is schematic only.
   2. Size piping and design actual piping layout, including oil traps, double risers, and specialties. Coordinate the number of circuits, required pipe and tube sizes as needed to accommodate the provided cooling coils and condensing units.
   3. Verify the equipment to be provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

B. Field quality-control test reports.

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

1.4 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-454B
   1. Suction Lines for Air-Conditioning Applications: 300 psig
   2. Suction Lines for Heat-Pump Applications: 535 psig
   3. Hot-Gas and Liquid Lines: 535 psig

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

A. Copper Tube and Fittings
   1. Copper Tube: ASTM B 280, Type ACR
   2. Wrought-Copper Fittings: ASME B16.22
   3. Wrought-Copper Unions: ASME B16.22
   4. Silver Solder: Cadmium-free high-silver alloy consisting of at least 45% silver
   5. Brazing Filler Metals: Phosphorus/copper/silver alloy consisting of 15% silver

B. Flexible Connectors
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket
   2. End Connections: Socket ends
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly
   4. Pressure Rating: Factory test at minimum 500 psig
   5. Maximum Operating Temperature: 250° F

2.2 VALVES AND SPECIALTIES

A. Provide all necessary valves and specialties as needed to provide an operational system. Components may include the following items:
   1. Diaphragm Packless Valves
   2. Packed-Angle Valves
   3. Check Valves
   4. Service Valves
   5. Solenoid Valves
   6. Safety Relief Valves
   7. Thermostatic Expansion Valves
   8. Hot-Gas Bypass Valves
   9. Strainers
   10. Moisture/Liquid Indicators
   11. Replaceable-Core Filter Dryers
   12. Permanent Filter Dryers
   13. Mufflers
   14. Receivers
   15. Liquid Accumulators

B. Coordinate refrigerant system configuration with equipment manufacturer.

## 2.3 REFRIGERANTS

A. The following refrigerants are acceptable for comfort cooling related systems.
   1. ASHRAE 34, R-454b
   2. ASHRAE 34, R-32

# PART 3 - EXECUTION

## 3.1 PIPING APPLICATIONS

A. Suction Lines for Conventional Air-Conditioning Applications: Copper, Type L or ACR, drawn-temper tubing and wrought-copper fittings with brazed or silver soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type L or ACR, drawn-temper tubing and wrought-copper fittings with brazed or silver soldered joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type L or ACR, drawn-temper tubing and wrought-copper fittings with brazed or silver soldered joints.

## 3.2 SYSTEM CONSTRAINTS

A. Install a full-sized, three (3)-valve bypass around filter dryers and all equipment that require routine servicing.

B. Design refrigeration system to operate at an ambient temperature of 95˚Fand a minimum outside air temperature of 30˚F.

## 3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

B. Install refrigerant piping according to the appropriate requirements of ASHRAE 15, including A2L refrigerants as required.

C. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping free of sags and bends.

F. Install fittings for changes in direction and branch connections.

G. Arrange piping to allow inspection and service of refrigeration equipment.

H. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

I. Install refrigerant piping in protective conduit where installed belowground.

J. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

K. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Use double-suction riser for maximum compressor efficiencies if load variation is expected.
   4. Install traps and double risers to entrain oil in vertical runs.
   5. Liquid lines may be installed level.

L. 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.

M. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

N. Install sleeves for piping penetrations of walls, ceilings, and floors.

O. Install sleeve seals for piping penetrations of concrete walls and slabs.

P. Install escutcheons for piping penetrations of walls, ceilings, and floors.

Q. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

R. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

S. Install flexible connectors at compressors.

## 3.4 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."

## 3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections
   1. Comply with ASME.
   2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
   3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
      a. Fill system with nitrogen to the required test pressure.
      b. System shall maintain test pressure at the manifold gage throughout duration of test.
      c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
      d. Remake leaking joints using new materials and retest until satisfactory results are achieved.

## 3.6 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 or manufacturers' required level. If vacuum holds for twelve (12) hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
   4. Charge system with a new filter-dryer core in charging line.

## 3.7 ADJUSTING

A. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

B. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

C. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Open shutoff valves in condenser water circuit.
   2. Verify that compressor oil level is correct.
   3. Open compressor suction and discharge valves.
   4. Open refrigerant valves except bypass valves that are used for other purposes.
   5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

D. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

**END OF SECTION**

**SECTION 232923**

**VARIABLE FREQUENCY DRIVES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install variable frequency controllers for variable torque applications, including HVAC (in Variable Air Volume, or VAV, fan control applications) and pump control (for chilled water system primary and secondary pump control) indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Disconnect Switches – Section 262728

B. Motor Controllers – Section 262900

C. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems; National Electrical Manufacturers Association.

D. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives; National Electrical Manufacturers Association.

E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association.

F. NETA STD ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems; International Electrical Testing Association.

G. NFPA 70 - National Electrical Code; National Fire Protection Association.

1.3 SUBMITTALS

A. See Division 1 Administrative Requirements, for submittal procedures.

B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details. Include reflected harmonic distortion levels AFTER the addition of line reactors for both input voltage and current.

C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

E. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

A. Allen-Bradley, PowerFlex 700 series (BASIS OF DESIGN)

B. ABB, ACH550 series

C. Yaskawa

D. Danfoss Graham

E. Toshiba

F. GE Industrial

G. Square D

H. Siemens

I. Substitutions: Prior approval only.

J. Design Basis: The above listing of manufacturer’s series names above does not relieve manufacturer from meeting all technical requirements listed in this specification. Any discrepancy in requirements compared to available features shall be communicated to the Engineer prior to bidding. Models of allowed manufacturers that do not have listed design basis equipment must meet all technical requirements AND be basically equivalent to the “Basis of Design”.

### 2.2 DESCRIPTION

A. Variable Frequency Controllers: Controllers shall be suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.
   1. Employ microprocessor-based inverter logic isolated from power circuits.
   2. Employ pulse-width-modulated inverter system.
   3. Design for ability to operate controller with motor disconnected from output.
   4. Design to attempt five automatic restarts following fault condition before locking out and requiring manual restart.

5. Four (4)-Mode Starting: Current Limit, Torque Ramp, Current Ramp, Voltage Ramp.
6. Four (4)-Mode Stopping: Free-wheel, Torque Ramp, Time Ramp, Dynamic Brake.

B. Enclosures: Enclosed, NEMA 1 enclosure

C. Finish: Manufacturer's standard enamel.

## 2.3 OPERATING REQUIREMENTS

A. Rated Input Voltage: 480 volts, three (3) phase, 60 Hertz.

B. Motor Nameplate Voltage: 460 volts, three (3) phase, 60 Hertz.

C. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.

D. Operating Ambient: 0° C to 40° C.

E. Minimum Efficiency at Full Load: 95 percent.

F. Volts Per Hertz Adjustment: Plus or minus 10 percent.

G. Current Limit Adjustment: 60 to 110 percent of rated.

H. Acceleration Rate Adjustment: 0.5 to 30 seconds.

I. Deceleration Rate Adjustment: 1 to 30 seconds.

J. Input Signal: 4 to 20 mA DC.

## 2.4 COMPONENTS

A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current.

B. Status Indicators: Separate indicators for overcurrent, overvoltage, ground fault, overtemperature, and input power ON.

C. Control devices: Furnish HAND-OFF-AUTOMATIC selector switches and indicating lights.

D. Include undervoltage release.

E. Control Power Source: Separate circuit.

F. Operator Interface: Unit-mounted display and keypad.

G. Safety Interlocks: Furnish terminals for remote contact to inhibit starting under both manual and automatic mode.

H. Control Interlocks: Furnish terminals for remote contact to allow starting in automatic mode.

I. Input power disconnect switch: Include integral fused disconnect switch on the line side of each controller.

J. Isolation/Bypass:
   1. 3-contactor bypass configuration.
   2. Refer to plans for units requiring bypass package.

K. Cooling Fans: Drives and enclosures that require cooling fans shall derive power for fans via circuits that allow power only while the drive is in operation and for a short time afterwards to cool down. Continuously-running fans are not allowed.

L. Power Quality
   1. Line Side: The drive shall limit harmonic distortion reflected onto the building's distribution system to a voltage and current distortion level as defined by IEEE 519 for general system applications. Harmonic attenuation shall be provided by the use of line reactors (minimum 3%).

M. Building Automation System Interface: The drive will be compatible with the building automation system without the addition of customer provided equipment.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify that surface is suitable for controller installation.

B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.

C. Verify that field measurements are as indicated on shop drawings.

### 3.2 INSTALLATION

A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Select and install overload heater elements in motor controllers to match installed motor characteristics.

D. Provide engraved plastic nameplates; refer to Section 260553 for product requirements and location.

E. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

## 3.3 MANUFACTURER'S FIELD SERVICES

A. Provide the service of the manufacturer's field representative to prepare and start controllers.

## 3.4 ADJUSTING

A. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

## 3.5 DEMONSTRATION

A. Demonstrate operation of controllers in automatic and manual modes.

**END OF SECTION**

**SECTION 233113**

**METAL DUCTWORK**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all work required to provide and install the Ductwork Insulation indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. National Fire Protection Association (NFPA)

B. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)

C. Definition
   1. Low Pressure
      a. 2 inch W.G. Pressure Class: Ductwork systems up to 2 inch w.g. positive or negative static pressure with velocities less than or equal to 1500 fpm.
   2. Medium Pressure
      a. 3 inch W.G. Pressure Class: Ductwork systems over 2 inch w.g. and up to 3 inch W.G. positive or negative static pressure with velocities less than or equal to 2500 fpm.
      b. 4 inch W.G. Pressure Class: Ductwork systems over 3 inch w.g. and up to 4 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
      c. 6 inch W.G. Pressure Class: Ductwork systems over 4 inch w.g. and up to 6 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.

1.3 SUBMITTALS

A. Shop Drawings
   1. Submit CAD drawn duct layout drawings for all project ductwork. Submit detailed elevations and sections where required to convey complete scope of work. Shop drawings shall be based on other trades contract drawings and field dimensions. Submit drawings on full size paper at 1/4” = 1’-0” scale.
   2. Layouts for areas in which it may be necessary to deviate substantially from layout shown on the Drawings. Show major relocation of ductwork and major changes in size of ducts. Minor transitions in ductwork, if required due to job conditions, need not be submitted as long as the duct area is maintained.
   3. Layout and fabrication details for cooking equipment exhaust ductwork.
   4. Layouts of mechanical equipment rooms and penthouses.

5. Details of intermediate structural steel members required to span main structural steel for the support of ductwork.
6. Method of attachment of duct hangers to building construction.

B. Coordinate shop drawings with related contractors prior to submission.

C. Product Data: Material, gauge, type of joints, sealing materials, and reinforcing for each duct size range, including sketches or SMACNA plate numbers for joints, method of fabrication and reinforcing. Include ACGIH figure numbers for hoods if applicable.

## 1.4 QUALITY ASSURANCE

A. SMACNA: Gauges of materials, fabrication, reinforcement, sealing requirements, installation, and method of supporting ductwork shall be in accordance with the following SMACNA manuals, unless otherwise shown or specified:
1. HVAC Duct Construction Standards
2. Round Industrial Duct Construction Standard
3. Rectangular Industrial Duct Construction Standard

B. Unless otherwise shown or specified, follow the Hood Design Data, and Construction Guidelines for Local Exhaust Systems from the ACGIH Industrial Ventilation Manual.

C. Conform to the applicable requirements of NFPA 90A, 90B, 91, 96, and 101.

# PART 2 - PRODUCTS

## 2.1 MATERIALS

A. Sheet Metal
1. Aluminum: ASTMB-209, Alloy 3003, Temper H-14.
2. Carbon Steel: 16 gauge black iron
3. Galvanized Steel: ASTM A653, ASTM A924, Class LFQ (lock forming quality), coating designation G-60.
4. Galvannealed Steel: ASTM A653, ASTM A924, Class LFQ (lock forming quality), coating designation A-40 (A60 outdoor or in humid environments).
5. Stainless Steel: AISI Types 302, 304 and 316, as specified.

B. Duct Hangers
1. Strap Hangers: Same material as ducts, except that hangers for stainless steel ducts in unfinished spaces may be galvanized steel.
2. Rod Type Hangers: Mild low carbon steel, unless otherwise specified; fully threaded or threaded each end, with 2 removable nuts each end for positioning and locking rod in place. Unless stainless steel, galvanized or cadmium plated; shop coat with metal primer.

C. Miscellaneous Fasteners and Upper Hanger Attachments
   1. Sheet Metal Screws, Machine Bolts and Nuts: Same material as duct, unless otherwise specified.
   2. Concrete Inserts: Steel or malleable iron, galvanized; continuously slotted or individual inserts conforming with MSS SP-58, Types 18 & 19, Class A-B.
   3. C Clamps: Fee & Mason Co.'s 255L with locking nut, and 255S with retaining strap.
   4. Metal Deck Ceiling Bolts: B-Line Systems, Inc.'s Fig. B3019.
   5. Welding Studs: Erico Fastening Systems, capacitor discharge, low carbon steel, copper flashed.
   6. Structural (carbon) Steel Shapes and Steel Plates: ASTM A36, shop primed.
   7. Stainless Steel Shapes and Plates: ASTM A276 and ASTM A666.
   8. Machine Bolt Expansion Anchors
      a. Non-caulking single unit type: FS FF-S-325, Group II, Type 2, Class 2, Style 1.
      b. Non-caulking double unit type: FS FF-S-325, Group II, Type 2, Class 2, Style 2.
      c. Self-drilling type: FS FF-S-325, Group III, Types 1 and 2.

## 2.2 FABRICATION – GENERAL

A. Refer to the ductwork application schedule on the drawings for the types and material usage for the various ductwork types required.

B. Duct sizes shown on the Drawings are inside clear dimensions available for air movement. Verify with duct construction method to determine exterior dimensions for layout and fabrication purposes.

C. Fabricate ductwork from galvanized sheet metal, except as follows:
   1. Fabricate the following ductwork from aluminum:
      a. Inlet and discharge ductwork connected to cooling towers and evaporative condensers.
      b. Exhaust ductwork from shower, locker, can washing and steam service rooms, and swimming pool areas.
      c. Dryer exhaust ductwork. Aluminum ductwork for dryer exhaust shall be a minimum of 26 gauge.
   2. Fabricate the following ductwork from galvannealed steel:
      a. Ductwork in exposed areas that will be painted.

D. Dissimilar Metals: Separate dissimilar metals used for ductwork with 12 oz vinyl coated woven fiberglass duct connector fabric, such as Duro Dyne's Glasseal. No separation is required between screws or rivets and the materials in which they are inserted.

## 2.3 FABRICATION OF STAINLESS STEEL DUCTS

A. Use minimum No. 18 gauge for exhaust ducts connected to cooking equipment hoods. Use minimum No. 20 gauge for exhaust ducts connected to other hoods. Use miniumum 26 gauge for dryer exhaust ducts.

B. Use stainless steel reinforcing members for ducts in finished spaces and galvanized steel in unfinished spaces.

C. Longitudinal Seams for Dishwashing, and Other Scullery Equipment Exhaust Ducts: Form double corner seams, or Pittsburgh lock seams.
   1. Fabricate elbows and transitions with Pittsburgh lock seams.
   2. Fabricate double compounded elbows and other complex fittings with double corner seams.
   3. Locate seams in horizontal ducts at top corners of ducts, unless otherwise approved in writing.
   4. Locate seams in vertical ducts at rear corners of ducts.

D. All exposed stainless steel ductwork shall have a #3 finish.

## 2.4 REGISTERS AND GRILLES INSTALLED IN EXPOSED DUCTWORK

A. Frames are not required for registers and grilles installed directly in un-insulated exposed ductwork.

B. Cut openings in ducts, forming a double thickness of metal, to attach registers or grilles with sheet metal screws. Bend back edges of openings into duct, on all four (4) sides, a minimum of 1 inch to provide the thickness of metal stated above. Provide felt or sponge rubber gasketing, all four (4) sides of duct openings, for supply grilles and supply registers.

## 2.5 AIR DIFFUSERS INSTALLED IN EXPOSED DUCTWORK

A. Frames are not required for diffusers installed directly in un-insulated exposed ductwork.

B. Cut and form openings in ducts, to accommodate the specified volume control damper and adjustable equalizing grid assembly. Reinforce openings as required and approved. Provide felt or sponge rubber gasketing, around duct opening, for supply diffuser assemblies.

## 2.6 VIBRATION ISOLATION FOR DUCTWORK

A. Type: Combination rubber and spring type designed for insertion in a split hanger rod for isolating ductwork from the overhead construction.

   1. Approved isolators: Amber Booth Type BSSR, Korfund Type VX, Mason Industries, Type DNHS, Vibration Eliminator Co. Type SNRC and Vibration Mountings and Controls Type RSH.

PART 3 - EXECUTION

## 3.1 INSTALLATION - GENERAL

A. Install ductwork to allow maximum headroom. Properly seam, brace, stiffen, support, and render ducts mechanically airtight. Adjust ducts to suit job conditions. Dimensions may be changed as approved if cross sectional area is maintained.

B. Provide necessary transformation pieces, and flexible fabric connections for ductwork connected to air handling equipment or air inlet and outlet devices. Flexible fabric connections installed at equipment exterior to the building shall be rated for UV exposure and suitable for exterior use per ASTM G155 leasing requirements. Metal for these connections shall be aluminum or stainless steel, galvanized connections shall not be allowed.

## 3.2 SEALING SEAMS, JOINTS, AND PENETRATIONS

A. Seal ductwork in accordance with the SMACNA Manual except for the following:
   1. Ductwork Specified to be Insulated: Conform with Seal Class A for all pressure classes.
   2. Cooking Equipment Exhaust Ductwork: Conform with NFPA 96.
   3. Horizontal Ductwork for Dishwashing, and Other Scullery Equipment Exhausts
      a. Continuously solder transverse joints vaportite along bottom, and up both sides two (2) inches minimum.
      b. Continuously solder longitudinal seams vaportite if seams are approved to be located at bottom of duct.
   4. Exhaust ductwork joints shall not use sheetmetal screws or other fasteners that protrude into the ductwork to catch lint and debris. Ducts shall insert and adjoin to the next duct or fitting in the direction of airflow. Seal all joints and seams vapor tight with ductwork foil tape.
      a. Commercial dryers or dryer exhaust systems serving multiple appliances shall utilize flanged and gasketed connections.

## 3.3 HANGERS FOR DUCTS, UNDER 2 INCHES W.G.

A. Install hangers for ducts as specified in the SMACNA Manual, with the following exceptions:
   1. Rectangular ducts up to 42 inches wide, not having welded or soldered seams, and supported from overhead construction; extend strap hangers down over each side of the duct and turn under bottom of duct a minimum of two (2) inches. Secure hanger to duct with three (3) full thread sheet metal screws, one (1) in the bottom and two (2) in the side of the duct.
   2. Rectangular ducts 43 inches wide and over, and all sizes of duct with welded or soldered seams, and supported from overhead construction; use trapeze hangers.
   3. Prime coat plain steel rods threaded at the site immediately after installation with metal primer.
   4. Dryer exhaust ductwork shall be supported at 48 inch intervals.

## 3.4 HANGERS FOR DUCTS, 2 INCHES W.G. AND OVER

A. Install hangers for ducts as specified in the SMACNA Manual, with the following exceptions:
   1. Support rectangular ducts with welded seams, regardless of size, by means of trapeze hangers, framed all four (4) sides. Provide minimum 1 x 1 x 1/8 inch angle iron framing for duct having a maximum side dimension up to and including 36 inches in size. Install framing snug to all four (4) sides of duct.

## 3.5 UPPER HANGER ATTACHMENTS

A. General
   1. Secure upper hanger attachments to structural steel or steel bar joists wherever possible.
   2. Do not use drive-on beam clamps, flat bars or bent rods, as upper hanger attachments.
   3. Do not attach hangers to steel decks which are not to receive concrete fill.
   4. Do not attach hangers to precast concrete planks less than 2-3/4 inches thick.
   5. Avoid damage to reinforcing members in concrete construction.
   6. Metallic fasteners installed with electrically operated or powder driven tools may be used as upper hanger attachments, in accordance with the SMACNA Manual, with the following exceptions:
      a. Do not use powder driven drive pins or expansion nails.
      b. Do not attach powder driven or welded studs to structural steel less than 3/16 inch thick.
      c. Do not support a load, in excess of 250 lbs from any single welded or powder driven stud.
      d. Do not use powder driven fasteners in precast concrete.

B. Attachment to Steel Frame Construction: Provide intermediate structural steel members where required by ductwork support spacing. Select steel members for use as intermediate supports based on a minimum safety factor of five (5).
   1. Secure upper hanger attachments to steel bar joists at panel points of joists.
   2. Do not drill holes in main structural steel members.

C. Attachment to Concrete Filled Steel Decks
   1. New Construction: Install metal deck ceiling bolts.
   2. Existing Construction: Install welding studs (except at roof decks).
   3. Do not attach hangers to decks less than 2-1/2 inches thick.

D. Attachment to Existing Cast-In Place Concrete
   1. Secure hangers to overhead construction with self drilling type expansion anchors and machine bolts.
   2. Secure hanger attachments required to be supported from wall or floor construction with single unit expansion anchors or self drilling type expansion anchors and machine bolts.

E. Attachment to Cored Precast Concrete Decks (Flexicore, Dox Plank, Spancrete, etc.): Toggle bolts may be installed in cells for the support of ducts up to a maximum of 60 inches in width.

F. Attachment to Hollow Block or Hollow Tile Filled Concrete Decks
   1. New Construction: Omit block or tile and pour solid concrete with cast-in-place inserts.

2. Existing Construction: Break out block or tile to access and install machine bolt anchors at highest practical point on side of web.

G. Attachment to Waffle Type Concrete Decks
1. New Construction: Install cast-in-place inserts.
2. Existing Construction: Install machine bolt expansion anchors at highest practical point on side of web.

H. Attachments to Precast Concrete Tee Construction
1. Secure hangers to tees by any of the following methods:
a. Tee hanger inserts between adjacent flanges.
b. Install double unit expansion anchors and machine bolts at highest practical point on side of web.

I. Attachment to Wood Construction
1. Secure strap hangers to the sides of wood beams with one (1) No. 18 x 1-1/2 inch long (minimum) wood screws or two (2) No. 16 x 1-1/2 inch long (minimum) drive screws. Do not hammer in wood screws.
2. Secure rod hangers to angle iron clip angles, bolted or screwed to the sides of the wood beams with 3/8 inch bolts or 3/8 inch lag screws. Install hanger rods with a threaded end through a hole in the angle, secured with a double nut, one (1) above and one (1) below the angle. Do not use lag screws in wood beams, having a nominal face width under 2 inches. Install bolts or lag screws in the side of beams at mid-point or above.
3. Pre-drill holes for lag screws 1/8 inch in diameter less than the root diameter of the lag screw thread.
4. Where wood trusses are approved to support ductwork, hangers may be attached only to the bottom chord. Method of attachment must be specifically approved.
5. Do not secure hanger attachments to nailing strips resting on top of steel beams.

## 3.6 DUCT RISER SUPPORTS, UNDER 2 INCHES W.G.

A. Support vertical round ducts by means of double-ended split steel pipe riser clamps bearing on floor slabs or adjacent structural members, at every other floor through which the riser passes.

B. Unless otherwise specified or shown on the drawings, support vertical rectangular ducts by means of two steel angles, secured to duct and resting on floor slab or adjacent structural steel member, at every other floor through which the duct passes. Size supports as follows:

| MAX. SIDE DIMENSION (inches) | SUPPORT ANGLE (inches) | SECURE TO DUCT WITH | MIN BEARING AT EACH END (inches) |
|---|---|---|---|
| 36 | 1 x 1 x 1/8 | Screws | 2 |
| 48 | 1-1/2 x 1-1/2 x 1/8 | Bolts | 3 |
| 60 | 2 x 2 x 1/8 | Bolts | 3 |
| 61 - up | 2-1/2 x 2-1/2 x 3/16 | Bolts | 4 |

3.7 DUCT RISER SUPPORTS, 2 INCHES W.G. AND OVER

A. Support vertical round ducts by means of double-ended split steel pipe riser clamps welded to the ducts and bearing on floor slabs or adjacent structural members, at every other floor through which the riser passes.

B. Support vertical rectangular ducts by means of two steel angles or channels, anchor bolted to floor slab or adjacent structural member at every other floor through which the riser passes. Secure steel angles or channels to a transverse joint by means of 3/8 inch bolts, or by welding. Size supports as follows:

| MAXIMUM SIDE DIMENSION (inches) | SUPPORT ANGLE (inches) | SUPPORT CHANNEL (inches) | MINIMUM BEARING AT EACH END (inches) |
|---|---|---|---|
| 36 | 1 x 1 x 1/8 | 1 x 1/2 x 1/8 | 2 |
| 48 | 1-1/2 x 1-1/2 x 1/8 | 1-1/2 x 3/4 x 1/8 | 3 |
| 60 | 2 x 2 x 1/8 | 2 x 1 x 1/8 | 3 |
| 61 - up | 2-1/2 x 2-1/2 x 3/16 | 2 x 1 x 3/16 | 4 |

3.8 VIBRATION ISOLATION FOR DUCTWORK

A. Install vibration isolation in accordance with the manufacturer’s printed installation instructions, unless otherwise specified.

B. Install in locations shown or scheduled on the Drawings.

C. High Velocity Ductwork Installed within Mechanical Equipment, Machine and Penthouse Mechanical Equipment Rooms: Provide combination rubber and spring type isolators, designed for insertion in a split hanger rod for overhead supported ductwork and double rubber-in-shear isolators for floor supported ductwork. Provide isolators designed for a static deflection of 1/2 inch.

3.9 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state, and local requirements, referenced standards, and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer’s published recommendations.

C. Cleanliness
   1. Before installing ductwork, wipe ductwork to a visibly clean condition.
   2. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.

3. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.
4. Provide openings in ductwork where required to accommodate thermometers, controllers, and other devices. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring. Sleeve of pitot tube opening shall be no more than one inch long. Opening shall be one inch wide to accept pitot tube.
5. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
6. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
7. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use polished stainless steel for ductwork exposed to view and mill stainless steel for ducts where concealed.
8. All visible welds in ductwork between biosafety cabinets, canopy hoods and fume hoods and the ceiling shall be ground and polished.
9. Slope duct toward grilles for moisture-laden ducts. Provide drain and trap at elbow of main moisture exhaust duct system.

D. Exposed Ductwork
1. Remove all markings, stickers, and labels.
2. Completely clean the exterior of all ducts prior to painting, duct is to be painted prior to project completion.
3. All exposed ductwork shall have a ‘paintgrip’ finish to allow for normal paint application without additional field labor by the painter. See architectural drawings for areas with exposed ceiling to be painted.
4. Any ductwork deemed in unsightly by the Architect/Engineer/Owner will be replaced at the Contractor’s expense.

E. Hangers and Supports
1. All ductwork supports shall be in accordance with Table 4-1 (rectangular duct) and Table 4-2 (round duct) of the SMACNA Standards, with all supports directly anchored to the building structure.
2. Rectangular duct shall have at least one pair of supports on minimum 8’-0" (eight feet) centers. All horizontal round and flat oval ducts shall have ducts hangers spaced 10’-0" (ten feet) maximum.
3. Lower attachment of hanger to duct shall be in accordance with Table 4-4 of the SMACNA Standards.
4. Vertical ducts shall be supported where they pass through the floor lines with 1-1/2 inch x 1-1/2 inch x 1/4 inch angles for duct widths up to 60 inches. Above 60 inches in width, the angles must be increased in strength and sized on an individual basis considering space requirements.
5. Hanger straps on duct widths 60 inches and under shall lap under the duct a minimum of 1 inch and have minimum of one fastening screw on the bottom and two on the sides.
6. Hanger straps on duct widths over 60 inches shall be bolted to duct reinforcing with 3/8 inch bolts minimum.

## 3.10 DUCTWORK SYSTEM CLEANING

A. If the system has been operated without schedule filters or if the integrity of temporary closures has been compromised, Contactor shall have ductwork cleaned according to National Air Duct Cleaners Association (NADCA) Standards by a Certified Regular Member of the NADCA.

B. For ductwork supplying Clean Rooms or patient care areas, also sanitize the ductwork interior per NADCA standards with a biocidal agent approved by the EPA for use in HVAC systems.

C. Before turning the installation over to the Owner, Contractor shall certify that the air handling systems have only been operated with scheduled filters in place. Otherwise, Contractor shall present evidence that the ductwork cleaned as required above.

## 3.11 TESTING

A. A minimum of 25% of all medium and high pressure duct systems (positive or negative) shall be pressure tested according to SMACNA test procedures (HVAC Air Duct Leakage Test Manual) and ASHRAE Standard 90.1 requirements. The ductwork to be tested shall be 25% of the lineal feet of ductwork mains starting at the air handling unit or fan.
   1. Notify Owner minimum seven (7) calendar days in advance of leakage testing.
   2. Design pressure for testing ductwork shall be determined from the maximum pressure generated by the fan at the nominal motor horsepower selected.
   3. Total allowable leakage shall not exceed 1 percent of the total system design airflow rate.
   4. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
   5. Leaks identified during leakage testing shall be repaired by:
      a. Complete removal of the sealing materials.
      b. Thorough cleaning of the joint surfaces.
      c. Installation of multiple layers of sealing materials.
   6. The ductwork system to be tested, shall exclude connections downstream of the terminal units (i.e., ductwork shall be capped immediately prior to the terminal units, and tested as described above).
   7. After testing has proven that ductwork is installed and performs as specified, the terminal units shall be connected to ductwork and connections sealed with extra care. Contractor shall inform the Owner when joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage exists in the terminal unit connections/joints after the systems have been put into service, leaks shall be repaired as specified for other leaks.

B. All low-pressure duct systems (positive or negative) shall be inspected for visible and audible signs of leakage.

C. Leaks identified by inspection shall be repaired by
   1. Complete removal of the sealing materials.
   2. Thorough cleaning of the joint surfaces.
   3. Installation of multiple layers of sealing materials.

D. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

E. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.

**END OF SECTION**

**SECTION 233300**

**DUCTWORK ACCESSORIES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the ductwork accessories indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
1. Airflow Control Dampers and Spin-In Fittings
2. Fire Dampers, Smoke Dampers, and Combination Fire and Smoke Dampers
3. Flexible Duct
4. Flexible Duct Elbow Supports
5. Flexible Duct Connections
6. Duct Access Doors
7. Screens
8. Duct Test Holes
9. Turning Vanes
10. Remote Balancing Dampers
11. Pressure Relief Doors

1.2 REFERENCES

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
1. AMCA 500D – Laboratory Method of Testing Dampers for Rating
2. AMCA 500L – Laboratory Method of Testing Louvers for Rating
3. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
4. NFPA 101 - Life Safety Code
5. SMACNA - HVAC Duct Construction Standards
6. UL 33 - Heat Responsive Links for Fire-Protection Service
7. UL 555 – Standard for Fire Dampers
8. UL 555C – Standard for Ceiling Radiation Dampers
9. UL 555S – Standard for Smoke Dampers

1.3 SUBMITTALS

A. Product Data
   1. Provide product data for shop fabricated assemblies including, but not limited to, volume control dampers, duct access doors, and duct test holes. Provide product data for hardware used.

B. Record Documents

   1. Fire Dampers: The damper manufacturer's literature submitted for approval prior to the installation shall include performance data developed from testing in accordance with AMCA 500D standards and shall show the pressure drops for all sizes of dampers required at anticipated air flow rates. Maximum pressure drop through fire damper shall not exceed 0.05-inch water gauge.

   2. Combination Fire/Smoke Dampers: Assign identification numbers for each damper with corresponding number noted on Drawings. Provide air quantity, size, free area of damper, pressure drop and proposed velocity through each damper. Provide manufacturer's data of damper and its accessories or options. At Owner's request, provide two (2) dampers (18 inch x 12 inch) for the purpose of illustrating damper operation to Owner's operating and maintenance personnel.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 AIR FLOW CONTROL DAMPERS

A. Acceptable Manufacturers
   1. Greenheck
   2. Nailor Industries
   3. Pottorff
   4. Ruskin
   5. Tamco
   6. United Enertech
   7. Louvers & Dampers, Inc.
   8. NCA Manufacturing
   9. Air Balance

B. Furnish and install dampers where shown on the Drawings and wherever necessary for complete control of airflow, including all supply, return, outside air, and exhaust branches, "division" in main supply, return and exhaust ducts, and each individual air supply outlet. Where access to

dampers through a permanent suspended ceiling (gypsum board) is necessary, the Contractor shall be responsible for the proper location of the access doors.

C. Dampers larger than three (3) square feet in area shall be controlled by a self-locking splitter damper assembly.

D. Volume damper blades shall not exceed 48 inches in length or twelve inches in width and shall be of the opposed interlocking type. The blades shall be of not less than No. 16 gauge galvanized steel supported on one-half inch diameter rust-proofed axles. Axle bearings shall be the self-lubricating ferrule type.

E. Volume dampers and other manual dampers shall be carefully fitted, and shall be manually controlled by damper regulators as follows:
   1. On exposed non-insulated ductwork the locking quadrant shall be made with a base plate of 16-gauge cold-rolled steel and a heavy die cast handle designed with a 3/8 inch bearing surface. A 1/4 inch-20 zinc plated wing nut shall firmly lock the handle in place.
   2. On exposed externally insulated ductwork the regulator shall be 4-1/4 inch diameter, for 1/2 inch rod, designed for use on duct with insulation thickness specified for duct, and shall have four (4) 3/16 inch holes provided to rivet or screw regulator to the duct surface. The flange that covers the raw edge of the insulation shall be high enough so that it slightly compresses the insulation and holds insulation in place. The handle shall be 3/8 inch above the flange, and shall easily turn without roughing up the insulation.
   3. On concealed ductwork above inaccessible ceilings, the regulator shall be 2-5/8 inch diameter chromium plated cover plate that telescopes into the base, for 1/2 inch rod. Regulator shall be cast into a box for mounting in ceilings. Base shall be 1-1/2 inch deep. The cover shall be secured by two (2) screws that can be easily removed for damper adjustment.
   4. Furnish and install end bearings for the damper rods on the end opposite the quadrant.

F. Spin-in fittings may be used for duct taps to air devices and shall include dampers on all ducts to air devices (diffusers and grilles) even though a volume damper is specified for the air device. Spin-in fittings shall be similar to Flexmaster FLD with BO3 including a 2 inch build-out, nylon bushings, locking quadrant similar to Duro Dyne KR-3, and a 3/8 inch square rod connected to the damper with U-bolts. Spin-in fittings shall be sealed at the duct tap with sealant as specified herein. Determine location of spin-in fittings after terminal units are hung or after location of light fixtures are confirmed to minimize flexible duct lengths and sharp bends.

## 2.3 FIRE DAMPERS

A. Acceptable Manufacturers
   1. Greenheck
   2. Nailor Industries
   3. Pottorff
   4. Ruskin
   5. United Enertech
   6. Air Balance
   7. NCA Manufacturing
   8. Leader Industries

B. Each fire damper shall be constructed and tested in accordance with Underwriters Laboratories Safety Standard 555, latest edition. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating 165° F fusible link, and shall bear a U.L. label in accordance with Underwriters' Laboratories labeling procedures. Construct fire dampers such that damper frame material and curtain material are galvanized.

C. Fire dampers shall be curtain blade ”C” type and damper shall be constructed so that the blades and frame are out of the air stream to provide 100 percent free area of duct in which the damper is housed. NOTE: (Blades only out of the airstream represents “B” type damper which is not 100% free area).

D. Equip fire dampers for vertical or horizontal installation as required by location shown on Drawings. Install fire dampers in wall and floor openings utilizing steel sleeves, angles and other materials and practices as required to provide an installation equivalent to that utilized by the manufacturer when the respective dampers were tested by Underwriters Laboratories. Mounting angles shall be minimum 1-1/2 inch by 1-1/2 inch by 16 gauge and bolted, tack welded or screwed to the sleeve at maximum spacing of 12 inches and with a minimum of two (2) connections at all sides. Mounting angles shall overlap at least equal to the duct gauge as defined by the appropriate SMACNA Duct Construction Standard, latest edition, and as described in NFPA 90A. The entire assembly, following installation, shall be capable of closure with airflow in both directions at 4 inch water gauge static pressure at temperatures up to and withstanding 350° F.

E. All fire dampers shall be dynamic rated type.

F. Completely seal the damper assembly to the building components using manufacturer recommended material(s).

## 2.4 COMBINATION FIRE/SMOKE DAMPERS

A. Acceptable Manufacturers
   1. Greenheck
   2. Nailor Industries
   3. Pottorff
   4. Ruskin
   5. United Enertech
   6. NCA Manufacturing
   7. Air Balance

B. Provide one (1) damper motor for each 12 square feet of damper area.

C. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL Standard 555, Current Edition, and shall be further classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. Damper manufacturer shall have tested and qualified with UL, a complete range of damper sizes covering all dampers required by this Specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be no higher than Leakage Class II 20 CFM per square foot at 4 inches water gauge pressure). Maxi-

mum air pressure drop through each combination fire/smoke damper shall not exceed 0.10-inch water gauge at the design air quantity. (Note that this may require a larger damper than the connected duct size.) All ratings shall be dynamic.

D. Damper frame shall be minimum 20-gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non electrolytic materials construction to incorporate a friction free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze oilite sleeve type turning in an extruded hole in the frame or an extruded frame raceway. Dampers may be either parallel or opposed blade type. Blades shall be constructed with a minimum of 14-gauge equivalent thickness. Blade edge seal material shall be able to withstand 450° F. Jamb seals shall be flexible stainless steel compression type.

E. In addition to the leakage ratings specified herein, combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350° F Electric operators shall be installed by the damper manufacturer at the time of damper fabrication. Damper and operator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications for both dampers and operators. Manufacturer shall provide a factory-assembled sleeve. Sleeve shall be minimum 20-gauge for dampers where neither width nor height exceeds 48 inches or 16-gauge where either dimension equals or exceeds 48 inches.

F. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures at least 4 inches water gauge in the closed position, and 2000 fpm air velocity at 350° F in the open position.

G. Each combination fire/smoke damper, except as noted hereinafter, shall be equipped with a UL Classified firestat/releasing device. The firestat/releasing device shall electrically lock the damper in a closed position when the duct temperatures exceed 165° F and still allow the appropriate authority to operate the damper as may be required for smoke control functions. Damper must be operable while the temperature is above 350° F. Actuator/operator package shall include two (2) damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One (1) switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. The firestat/releasing device and position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm system, and remote indicating/control stations or building automation system (BAS).

H. Damper releasing device shall be mounted within the airstream. Device shall be activated and the damper shall close and lock when subjected to duct temperatures in excess of approximately 350° F.

I. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated on the Drawings, and shall be furnished and installed by the damper manufacturer as required by the U.L. rating mentioned above. Motors shall be electric to match the type of temperature control system specified elsewhere in this Specification. Furnish all required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system.

J. Furnish each damper in a square or rectangular configuration. Furnish and install sleeves manufactured by the approved damper manufacturer for each damper. Construct sleeves with square or rectangular to square, rectangular, round, or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturer's U.L. installation instructions. The entire assembly, following installation, shall operate smoothly and be capable of withstanding 6 inch water gauge static pressure.

K. Each combination fire/smoke damper shall be equipped with a Damper Test Switch. The damper test switch will have the ability to "cycle test" the fire/smoke damper by pushing and holding the test button until the damper has cycled.

L. All combination fire/smoke dampers shall be dynamic type.

M. Completely seal the damper assembly to the building components using manufacturer recommended material(s).

## 2.5 SMOKE DAMPERS

A. Acceptable Manufacturers
   1. Greenheck
   2. Nailor Industries
   3. Pottorff
   4. Ruskin
   5. United Enertech

B. Provide one (1) damper motor for each 12 square feet of damper area.

C. Each smoke damper shall be dynamic rated type and shall be further classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. Damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this Specification. Testing and UL qualifying a single damper size is not acceptable. Leakage rating under UL555S shall be no higher than Leakage Class II (20 CFM per square foot at 4 inches water gauge pressure). Maximum air pressure drop through each smoke damper shall not exceed 0.10-inch water gauge at the design air quantity. (Note that this may require a larger damper than the connected duct size.) All ratings shall be dynamic.

D. Damper frame shall be minimum 20-gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be stainless steel sleeve type turning in an extruded hole in the frame or an extruded frame raceway. Dampers shall be opposed blade type. Blades shall be airfoil shaped double skin construction. Blade edge seal material shall be silicone rubber designed to withstand 450° F. Jamb seals shall be Stainless Steel metal compression type.

E. In addition to the leakage ratings specified herein, smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350° F. Electric operators shall be installed by the damper manufacturer at the time of damper fabrication. Damper and operator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications

for both dampers and operators. Manufacturer shall provide factory-assembled sleeve. Sleeve shall be minimum 20-gauge for dampers where neither width nor heights exceeds 48 inches or 16-gage where either dimensions equals or exceeds 48 inches.

F. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4 inches water gauge in the closed position, and 2000 fpm air velocity in the open position.

G. The damper must be operable while the temperature is above 350° F. The actuator/operator package shall include two (2) damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One (1) switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. Position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm systems, and remote indicating/control stations (BAS).

H. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated on the Drawings, and shall be furnished and installed by the damper manufacturer as required by the UL rating mentioned above. Motors shall be electric to match the type of temperature control system specified elsewhere in this Specification. Furnish all required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system.

I. Furnish each damper in a square or rectangular configuration. Furnish and install sleeves manufactured by the approved damper manufacturer for each damper. Construct sleeves with square or rectangular to square, rectangular, round, or oval adapters as required. Install dampers in the sleeves in accordance with manufacturer's UL installation instructions. The entire assembly, following installation, shall be capable of closure with airflow in both directions at 4 inch water gauge static pressure at temperatures up to and withstanding 350° F.

J. Each smoke damper shall be equipped with a damper test switch. The damper test switch will have the ability to "cycle test" the fire/smoke damper by pushing and holding the test button until the damper has cycled.

K. All smoke dampers shall be dynamic type.

L. Completely seal the damper assembly to the building components.

## 2.6 FLEXIBLE DUCTS

A. Acceptable Manufacturers
   1. Flexmaster U.S.A., Inc.
   2. McGill AirFlow LLC.
   3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
   4. Thermaflex

B. Insulated, Flexible Duct:
   1. Certifications:
      a. UL 181,

b. ETL Class 1
c. NFPA 90A and 90B
d. Greenguard

2. Construction:
   a. Single ply inner liner constructed of chlorinated polyethylene
   b. Corrosion resistant galvanized steel core
   c. Fibrous glass insulation with a minimum value of R-6.
   d. Polyethylene vapor barrier film
3. Pressure Rating: 6-inch wg positive and 2-inch wg negative
4. Maximum Air Velocity: 5000 fpm
5. Temperature Range: -10° F to 160° F
6. Flame spread rating less than 25
7. Smoke developed rating of less than 50

## 2.7 FLEXIBLE DUCT ELBOW SUPPORTS

1. Acceptable Manufacturers
   a. Build Right Products - FlexRight
   b. Thermaflex – FlexFlow Elbow
   c. RPS - FlowRite
2. Construction
   a. Universal-mount, 1-piece, fully adjustable, radius-forming brace to support 4-inch through 16-inch diameter flexible air ducts.
   b. Classified: UL 2043.
   c. Material: 100 percent recycled copolymer polypropylene.
   d. Support Frame Radius: 8 inches.
   e. Compliance for Flexible Duct Radius:
      1) SMACNA HVAC Duct Construction Standards.
      2) ASHRAE Advanced Energy Design Guides.
      3) ADC Flexible Duct Performance and Installation Standards.

## 2.8 FLEXIBLE CONNECTIONS

A. Where ducts connect to equipment, flexible connections shall be made using “Flexmaster TL-M” or “Ventglas” fabric that is temperature-resistant, fire-resistant, waterproof, mildew-resistant and practically airtight, weighing approximately thirty ounces (30 oz.) per square yard.

B. Material used outdoors shall be resistant to ultra-violet sunrays. There shall be a minimum of 1/2" slack in the connections, and a minimum of 2 1/2" inches distance between the edges of the ducts. This does not apply to air handling units with internal isolation. A more rugged flexible material that is resistant to ultra-violet rays needs to be used when connecting an exhaust fan or exhaust air plenum to ductwork.

## 2.9 DUCT ACCESS DOORS

A. Acceptable Manufacturers
   1. Greenheck

2. Kees
3. Nailor Industries
4. Pottorff
5. Ruskin

B. Furnish and install in the ductwork, hinged rectangular, or round "spin-in" access doors to provide access to the following items:
   1. Major changes of direction in horizontal ducts connected to cooking equipment hoods and vertical grease duct risers as required by code for system cleaning. Refer to NFPA 96 and Specification Section 233113 for additional requirements.
   2. Motor operated dampers.
   3. Manually operated volume control devices.
   4. Fire, fire/smoke, and smoke dampers.
   5. Mixed air plenums
   6. In-line damper actuators installed in air stream.
   7. Heating coils (install upstream)
   8. Duct mounted humidifiers (upstream and downstream)
   9. Airflow stations
   10. Air filters replacement doors
   11. All locations where operating parts of any kind are installed in the ductwork and elsewhere as indicated on the plans.

C. Access doors are not required, where a manually operated damper has an exposed damper regulator, with an indicating quadrant.

D. Where ductwork is insulated, access doors shall be double skin doors with 1” of insulation in the door.

E. Door Size
   1. Door opening shall be adequately sized and positioned to allow for maintenance / replacement of any components located inside the ductwork. Based on the maximum duct dimension the following access door size minimum requirements are as follows:
      a. 8” max duct dimension - One (1)-Hand or Inspection Access: 8” x 6” access door
      b. 12” max duct dimension - Two (2)-Hand Access: 12” x 10” or 10” diameter access door
      c. 18” max duct dimension - Head and Hand Access: 16” x 12” or 16” diameter access door
      d. 26” max duct dimension - Head and Shoulders Access: 24” x 16” or 22” diameter access door
      e. 30” max duct dimension - Body Access: 26” x 14” or 24” diameter access door
      f. All other sizes - Body plus Ladder Access: 26” x 18” or 26” diameter access door
   2. For duct access doors smaller than 16” x 12” Ventlok No. 90 sash style latches shall be used. For duct access doors 16” x 12” or larger Ventlok No. 260 latches shall be used.
   3. A minimum of two latches are required for all access doors are required. Provide additional latches as needed to ensure the access door is sealing properly and there is not noticeable air leakage or air noise associated with the access door.

F. All access doors shall have a continuous gasket.

G. Round access doors shall be "Inspector Series" spin-in type door as manufactured by Flexmaster USA.

H. Where access doors are installed above a gyp board ceiling, this Contractor shall be responsible for providing and installing a ceiling access door of adequate size to utilize the access door and position it in the proper location.

## 2.10 SCREENS

A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor which lead to, or are located outdoors.

B. Screens shall be No. 16 gauge, 1/2" mesh in removable frame as noted on drawings. Mesh and frame to be galvanized steel or aluminum as noted on the drawings.

C. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

## 2.11 TURNING VANES

A. Acceptable Manufacturers
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. METALAIRE, Inc.
   4. SEMCO Incorporated.
   5. Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
   1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. Contractor fabricated turning vanes are acceptable provided they meet the requirements in this section.

E. 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."

F. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

## 2.12 REMOTE DAMPER OPERATORS

A. Acceptable Manufacturers
   1. Pottorff; a division of PCI Industries, Inc.
   2. Ventfabrics, Inc.
   3. Young Regulator Company
   4. United Enertech

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass

D. Cable: Stainless steel

E. Wall-Box Mounting: Recessed, 3/4 inches deep or Recessed, 2 inches deep Surface

F. Wall-Box Cover-Plate Material: Stainless steel

G. Coordinate the location of the wall box with Architect / Engineer prior to installation.

H. Required Locations:
   1. Diffusers installed in hard ceilings.
   2. Where dampers are not accessible due to congested ceilings.

## 2.13 PRESSURE RELIEF ACCESS DOOR

A. Acceptable Manufacturers
   1. Greenheck
   2. Kees
   3. Pottorff
   4. Ruskin

B. Door and Frame Material: Galvanized sheet steel.

C. Door: Single wall Double wall with insulation fill with metal thickness applicable for duct pressure class.

D. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.

E. Factory set at 3-inch wg

F. Doors close when pressures are within set-point range.

G. Hinge: Continuous piano.

H. Latches: Cam.

I. Seal: Neoprene or foam rubber.

J. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Volume Dampers
1. 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.
2. Install steel volume dampers in steel ducts.
3. Install aluminum volume dampers in aluminum ducts.
4. Set dampers to fully open position before testing, adjusting, and balancing.
5. Position damper adjacent to the branch connection to the main when possible. Locate as far as from the opening it serves in all other instances.

D. Test Holes
1. Install test holes at fan inlets and outlets and elsewhere as indicated.
2. Install duct test holes where required for testing and balancing purposes.
3. Install test holes in locations as required to measure pressure drops across each item in the system, e.g., outside air louvers, filters, fans, coils, intermediate points in duct runs, etc.

E. Fire, Fire / Smoke, Smoke Dampers
1. Install fire, fire / smoke and smoke dampers according to UL listing.
2. Provide fire dampers, and combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
3. Fire and combination fire and smoke damper access panels shall be labeled with the words “Fire Damper” in letters not less than 1 inch (25 mm) in height.
4. Install each fire and combination fire and smoke damper square and true to the building. The installation shall not place pressure on the damper frame, but shall enclose the damper as required by UL555 and UL555S.

F. Duct Access Doors
1. Install duct access doors on sides or bottoms of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

a. On both sides of duct coils.
b. Upstream and downstream from duct filters.
c. At outdoor-air intakes and mixed-air plenums.
d. At drain pans and seals.
e. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
f. 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 may be pressure relief access doors. If pressure relief access doors are used, they shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
g. At each change in direction and at maximum 50-foot spacing.
h. Upstream or downstream from duct silencers.
i. Control devices requiring inspection.
j. Elsewhere as indicated.

2. Install access doors with swing against duct static pressure.
3. Label access doors according to Division 23 Section "Mechanical Identification" to indicate the purpose of access door.

G. Flexible Connections
1. Install flexible connectors to connect ducts to equipment.
2. Flexible fabric connections installed at equipment exterior to the building shall be rated UV exposure and suitable for exterior use per ASTM G155 testing requirements. Metal for these connections shall be aluminum or stainless steel, galvanized connections shall not be allowed.
3. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
4. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps.
5. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

H. Flexible Duct
1. Connect terminal units to supply ducts directly or with maximum 36-inch lengths of flexible duct. Do not use flexible ducts to change directions.
2. Fittings on terminal units and on sheet metal duct shall have flexible duct core slipped over duct and coupling or clamp tightened, then connection sealed with sealant. Insulation of flexible duct shall be slipped over connection to point where insulation abuts terminal unit or insulation on duct.
3. These insulation connections shall be sealed by embedding fiberglass tape in the sealant and coating with more sealant to provide a vapor barrier.
4. The terminal ends of the duct core shall be secured by compression coupling or stainless steel worm gear type clamp.
5. Connect diffusers to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.
6. Support flexible ducts as per SMACNA standards to prevent sags, kinks and to have 90 degree turns.

I. Flexible Duct Elbow Supports
   1. Install flexible duct elbow supports in accordance with manufacturer's instructions.
   2. Install flexible duct elbow supports over outer jacket of flexible ducts to form smooth, 90-degree bends to eliminate flexible duct kinks and airflow restrictions.
   3. Make bends in flexible ducts with minimum of 1-duct diameter centerline radius.
   4. Install flexible duct elbow supports at flexible duct 90-degree bends at following locations:
      a. Diffusers.
      b. Grilles.
      c. Registers.
      d. Duct take-offs and taps.
      e. Air devices with round inlets and outlets.
      f. HVAC equipment with round inlets and outlets.
      g. As indicated on the Drawings.

J. Balancing Dampers
   1. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing.
   2. Provide all dampers furnished by the BAS Provider in strict accordance with manufacturer’s written installation instruction and requirements of these Specifications.

K. Backdraft Dampers
   1. Provide backdraft dampers on exhaust fans or exhausts ducts where indicated. Install dampers so that they will open freely.

L. General Installation
   1. All installation shall be in accordance with manufacturer’s published recommendations.
   2. Furnish and install Ventlok No. 699 instrument test holes in the return air duct and in the discharge duct of each fan unit.
   3. Access doors as specified elsewhere shall be provided for access to all parts of the fire and combination fire and smoke dampers. Doors shall open not less than 90 degrees following installation and shall be insulated type where installed in insulated ducts.

## 3.2 TESTING

A. After each fire damper, smoke damper and combination fire and smoke damper has been installed and sealed in their prescribed openings and prior to installation of ceilings, Contractor shall, as directed by Owner, activate part or all dampers as required to verify “first-time” closure.

B. Activation of damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fire damper fusible link, and manually operating the fire/smoke damper through the electronic controls as appropriate.

C. Failure of damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly.

D. Coordinate smoke damper system interlock requirements with the fire alarm system.

**END OF SECTION**

**SECTION 233425**

**HVAC POWER VENTILATORS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all work required to provide and install the Power Ventilators indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section:
   1. Centrifugal roof ventilators.
   2. Upblast propeller roof exhaust fans.
   3. Centrifugal wall ventilators.
   4. Ceiling-mounting ventilators.
   5. In-line centrifugal fans.
   6. Propeller fans.

1.2 REFERENCES

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
   1. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
   2. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
   3. AMCA 99 - Standards Handbook
   4. ACMA 203 - Fan Application Manual - Field Performance Measurements
   5. AMCA 204 - Balance Quality and Vibration Levels For Fans
   6. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
   7. AMCA 300 - Reverberant Room Method for Sound Testing of Fans
   8. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
   9. NEMA MG1 - Motors and Generators
   10. NFPA 70 - National Electrical Code
   11. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
   12. UL 705 – Power Ventilators

1.3 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, including color charts
   5. Dampers, including housings, linkages, and operators
   6. Roof curbs
   7. Fan speed controllers

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.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

C. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal. The sound power levels must not exceed those indicated on Drawings.

D. Fabrication: Conform to AMCA 99.

E. Performance Base: 50 feet above sea level.

F. Fans shall be capable of operating stably at reduced loads imposed by means of variable speed drives.

G. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

H. UL Standard: Power ventilators shall comply with UL 705.

## 1.5 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.

## 1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

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

## 1.7 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. Belts: Two (2) sets for each belt-driven unit.

# PART 2 - PRODUCTS

## 2.1 CENTRIFUGAL ROOF VENTILATORS

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. Acme
   2. Twin City
   3. Greenheck
   4. Loren Cook Company.
   5. Pennbarry
   6. Soler & Palau
   7. Captiveaire

C. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

D. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
   2. Hinged Sub-base: Galvanized-steel hinged arrangement permitting service and maintenance.

E. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

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 and motor isolated from exhaust airstream.

G. Accessories
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
   3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   4. Gravity Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
   5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

H. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
   1. Configuration: Self-flashing for membrane roofs; with built-in cant for bituminous or built-up roofs.
   2. General exhaust fan roof curb height: Minimum 12 inches above finished roof level. Contractor to field coordinate required curb height based on roof insulation thickness.
   3. Grease exhaust fan roof curb height: Minimum 18” above finished roof level. Contractor to field coordinate required curb height based on roof insulation thickness.

4. Sound Curb: Curb with sound-absorbing insulation matrix.
5. Pitch Mounting: Manufacture curb for roof slope.
6. Metal Liner: Galvanized steel.
7. Burglar Bars: 1/2-inch-thick steel bars welded in place to form 6-inch squares.
8. Mounting Pedestal: Galvanized steel with removable access panel.
9. Vented Curb: Unlined with louvered vents in vertical sides.

I. Capacities and Characteristics:
   1. As scheduled on Drawings

## 2.2 CENTRIFUGAL WALL VENTILATORS

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. Acme
   2. Twin City
   3. Greenheck
   4. Loren Cook Company
   5. Pennbarry
   6. Soler & Palau
   7. Captiveaire

C. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

D. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

E. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

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 and motor isolated from exhaust airstream.

G. Accessories
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
   3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   4. Wall Grille: Ring type for flush mounting.

5. Gravity Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
6. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

H. Capacities and Characteristics
1. As scheduled on Drawings

## 2.3 CEILING-MOUNTED VENTILATORS

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. Broan Mfg. Co., Inc.
2. Greenheck
3. Loren Cook Company
4. NuTone Inc.
5. Pennbarry
6. Soler & Palau
7. Captiveaire

C. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

D. Housing: Steel, lined with acoustical insulation.

E. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

F. Grille: Plastic or Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

G. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

H. Accessories
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.

8. Manufacturer's standard roof jack or wall cap, and transition fittings.

I. Capacities and Characteristics:
   1. As scheduled on Drawings

## 2.4 IN-LINE CENTRIFUGAL FANS

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. Acme
   2. Greenheck
   3. Loren Cook Company
   4. Pennbarry
   5. Soler & Palau
   6. Captiveaire

C. Description: In-line, direct or belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

D. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

E. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing;with wheel, inlet cone, and motor on swing-out service door.

F. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

G. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

H. Accessories
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
   3. Companion Flanges: For inlet and outlet duct connections.
   4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

I. Capacities and Characteristics
   1. As scheduled on Drawings
   2. Vibration Isolators:

a. As scheduled on Drawings
3. Spark Arrestance Class: Refer to schedule.

## 2.5 PROPELLER FANS

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. Acme Engineering & Mfg. Corp.
2. Twin City
3. Loren Cook Company
4. Pennbarry
5. Greenheck

C. Description: Direct- or belt-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

D. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

E. Steel Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.

F. Fan Wheel: Replaceable, cast or extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

G. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
1. Service Factor Based on Fan Motor Size: 1.4.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
a. Ball-Bearing Rating Life: ABMA 9, $L_{10}$ of 100,000 hours
4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through five (5) hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

H. Accessories
1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.

3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

I. Capacities and Characteristics
1. As scheduled on Drawings
2. Vibration Isolators:
a. As scheduled on Drawings
3. Spark Arrestance Class: Refer to schedule.

## 2.6 MOTORS

A. Enclosure Type: Totally enclosed, fan cooled.

## 2.7 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. Support units using mounts and isolators as scheduled on drawings having a static deflection as scheduled. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

E. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.

F. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

G. Support suspended units from structure using threaded steel rods and hangers/supports having a static deflection as scheduled on Drawings. Vibration-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

H. Install units with clearances for service and maintenance.

I. 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. 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 verify connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

## 3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

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

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

**END OF SECTION**

**SECTION 233439**

**HIGH VOLUME, LOW SPEED FANS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all work required to provide and install the HVLS Fans indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section:

1. High Volume, Low Speed Fans (HVLS Fans)

1.2 REFERENCES

A. The most recently adopted of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
1. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
2. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
3. AMCA 99 - Standards Handbook
4. ACMA 203 - Fan Application Manual - Field Performance Measurements
5. AMCA 204 - Balance Quality and Vibration Levels For Fans
6. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
7. AMCA 300 - Reverberant Room Method for Sound Testing of Fans
8. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
9. NEMA MG1 - Motors and Generators
10. NFPA 13 - Standard for the Installation of Sprinkler Systems
11. NFPA 70 - National Electrical Code
12. UL 507 - Standard for Safety Electric Fans

1.3 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, including color charts
5. Fan speed controllers
6. Installation manuals

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.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.
   3. Air Velocity Profiles: CFD analysis showing airflow velocities (ft/min) in designed space.

C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Suspension assembly members.
   2. Size and location of initial access modules for acoustical tile.
   3. Open-Ceiling items including light fixtures, diffusers, grilles, speakers, sprinklers, and special moldings.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For HVLS to include in emergency, operation, and maintenance manuals.

## 1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal. The sound power levels must not exceed those indicated on Drawings.

D. Fabrication: Conform to AMCA 99.

E. Performance Base: 50 feet above sea level.

F. Fans shall be capable of operating stably at all speeds.

G. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

H. UL Standard: HVLS fans shall comply with UL 507.

1.5 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.

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.
   1. Warranty Period:
      a. For motor, including controls: 5 years from substantial completion.
      b. For Hub and Airfoils: Lifetime warranty for parts.
      c. For Labor: One year from substantial completion.

PART 2 - PRODUCTS

2.1 HIGH VOLUME, LOW SPEED FANS

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. Big Ass Fans
   2. Hunter Fan
   3. MacroAir Fans
   4. Skyblade

C. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-driven or gear-driven motor, with variable-speed motor controller.

D. Performance: See schedule on drawings for performance information.

E. Hub: Fabricated of high strength steel or aluminum. The hub shall be secured to the output shaft of the gearbox and shall incorporate retaining clips that shall restrain the hub/airfoil assembly.

F. Airfoils: The fan airfoils shall be constructed out of precision extruded aluminum alloy. The airfoils shall be connected by means of two (2) high strength locking bolts per airfoil. The airfoils shall be connected to the hub and interlocked with stainless steel retainers. Each airfoil shall be equipped with a winglet to enhance efficiency and effectiveness of the fan.

G. Gearbox: The gearbox shall incorporate a cast iron housing, double lip output seals, and a solid output shaft. Gearbox shall be sealed for ease of service with lifetime synthetic oil to exclude contaminants.

H. Mounting: The fan mounting system shall be designed for quick and secure installation on a variety of structural supports. The design shall allow for adjustments to be made after the mount is installed to the mounting structure to ensure the fan will hang level from the structure. All mounting bolts shall be SAE Grade 8 or equivalent.

I. Safety cables: The fan shall be equipped with a safety cable that provides an additional means of securing the fan assembly to the building structure.

J. Accessories
   1. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

## 2.2 MOTORS

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

B. Enclosure Type: Totally enclosed, fan cooled.

## 2.3 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.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Ceiling Units: Suspend units from structure; use steel wire or metal straps as required for stability.

C. Support suspended units from structure using manufacturers provided mounting arm.

D. Install units with clearances for service and maintenance.

E. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

## 3.2 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. 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 verify connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Verify lubrication for bearings and other moving parts.
   6. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

**END OF SECTION**

**SECTION 233600**

**AIR TERMINAL UNITS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following products as indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section:
1. Single duct variable volume terminal units
2. Precision air valves
3. Heating coils
4. Integral controls

1.2 REFERENCES

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
1. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
2. UL 181 - Factory-Made Air Ducts and Connectors.
3. ARI Standard 880 for Air Terminals.
4. ANSI/ASHRAE Standard 130 – Methods of Testing for Rating Ducted Air Terminal Units.

1.3 SUBMITTALS

A. Product Data:
1. Shop Drawings of product data indicating configuration, general assembly, access space required for service, and materials used in fabrication.
2. Electronic or Printed Catalog performance ratings that indicate nominal inlet size, CFM, applicable static pressure at the inlet or discharge of terminal unit, and noise criteria with sound octave band and sound decibel test in accordance with ARI 880, for the insulation lining selected.

B. Operation and Maintenance Data:
   1. Operating instructions and maintenance manuals indicating maintenance and repair data, parts lists.

## PART 2 - PRODUCTS

### 2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

### 2.2 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three (3) years documented experience.

B. The same manufacturer shall provide all products supplied for a certain air terminal unit type.

C. Manufacturers (Single Duct and Fan-Powered):
   1. Trane or preapproved equal

### 2.3 GENERAL CONSTRUCTION

A. Casing Single Wall Construction
   1. General:
      a. Units shall be constructed of 20 gauge galvanized steel.
      b. Units shall be provided with hanger brackets.
      c. All interior features of the boxes (such as mixing baffles, damper housings, etc.) shall be secured within the casing to avoid excessive movement or rattling with air movement or externally generated vibration.
      d. All external features of the terminal units shall be designed not to extend beyond the ends of the unit. For example, the actuator mounting brackets, etc. shall not extend beyond the plane of the inlet "bulkhead." The only exception shall be flow sensors installed in the inlet duct connections. Note that if a separate flow station is installed within a frame within the casing, then it shall be so installed not to allow airflow to bypass the flow measurement station.
   2. Insulation: Terminal unit casing shall be internally lined with a 1-inch thick, non-fiberglass insulation with a reinforced, non-porous foil facing. Insulation shall meet requirements of UL181 and NFPA 90A and shall not support bacterial or fungal growth.

3. Ductwork Connections: Construct units with inlet and discharge ductwork connections. The inlet ductwork connections shall extend a minimum of four (4) inches from the unit casing including an allowance for the installation of airflow station(s) or probe(s). The discharge connection shall include flange connection for use by the Contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly. External insulation shall be as specified in the Contract Documents for duct insulation with full vapor barrier.
4. Single Duct Casing Leakage: Assembled units shall be constructed such that casing leakage does not exceed 1.0 percent of terminal unit rated airflow at four (4) inches w.g. of inlet static pressure.

B. Damper
1. Damper blades shall be minimum 18 gauge galvanized steel or equivalent aluminum and shall be securely riveted or bolted through the damper shafts to assure no slippage of the blades. The damper shafts shall operate in rustproof self-lubricating bearings. Damper shafts penetrating the unit casings shall be sealed against leakage and bearings shall be installed for protection against wear in the casing penetration. Damper shafts shall be formed of, or cut from solid stock; no hollow shafts will be allowed. The dampers shall seat against gasketed stops or the dampers shall have gasketed edges. The dampers shall be constructed with the proper rigidity to prevent deformation of the damper blade. The damper actuator linkage, if used, shall be constructed of material of sufficient strength to avoid buckling under extreme loads. Also, linkages shall not allow play greater than five (5) degrees of damper movement. The controls for the dampers shall cause the dampers to fail in the position of last control (freeze in place), or fail to the open position.
2. Damper Leakage: Units shall be tested for inlet leakage with four (4) inches w.g. static pressure imposed. The maximum percent leakage from all tests shall be reported. The following table provides the maximum allowable damper leakage for the various size diameter inlets at four (4) inches w.g. differential pressure:

| INLET DIAMETER (INCHES) | MAXIMUM ALLOWABLE CFM (AREA X 2000 FPM) | MAXIMUM ALLOWABLE CFM DAMPER LEAKAGE |
|---|---|---|
| 6 | 393 | 6.0 |
| 8 | 698 | 11.0 |
| 10 | 1091 | 17.0 |
| 12 | 1571 | 20.0 |
| 14 | 2138 | 30.0 |

3. Flow Measurement: Airflow through the unit shall be accomplished by the use of a multi-port velocity pressure cross sensor or multi-axis flow ring devices with a minimum of four (4) radially distributed pick-up points connected to a center averaging chamber. The chamber is to be designed with adequate internal passages to prevent restrictions that can possibly contribute to control ‘hunting’. Calibration of each terminal unit with the building automation system (BAS) Provider’s controller is to be performed by the manufacturer prior to shipping the terminal unit to the Project Site.
4. Access plenum shall contain a minimum of a 9 inch diameter or 9 inch x 6 inch (or full unit width if less than 9 inches) access door as specified in Section 233300.

5. Door frame may be bolted, screwed, or flanged and sealed to the casing. Door shall be gasketed and shall be double-wall construction or insulated similar to main casing. Door shall be held in place with latches or other captive retainer devices.

C. Electric Heating Coil
1. Electric heating coils installed in conjunction with terminal units as scheduled on the Drawings shall be factory-installed.
2. Heaters shall be UL listed for zero clearance and meet all applicable requirements of the NEC.
3. Resistance wire shall be 80 percent nickel and 20 percent chromium.
4. Furnish heater with airflow switch, SCR power to heating elements, fan relay, control voltage transformer, high limit thermal cut-out, and a NEMA 1 electrical enclosure.
5. Provide with a unit mounted fused disconnect switch.

D. Unit Controls
1. General Performance: Flow stations, control transformers, disconnect switch, and controls enclosure shall be furnished, mounted and adjusted by the terminal unit manufacturer to assure their proper placement within the units. Install DDC controllers at factory. Controllers provided byTrane.
2. Control Performance: Assemblies shall be able to be reset to any airflow between zero and the maximum CFM shown on Drawings. To allow for maximum future flexibility, it shall be necessary to make only simple screwdriver or keyboard adjustments to arrange each unit for any maximum airflow within the ranges for each inlet size as scheduled on the Drawings. The control devices shall be designed to maintain the desired flow regardless of inlet flow deflection.
3. Control Sequences: The control sequence arrangements shall be as described on the Drawings. Terminal units shall be shipped from the manufacturer with all necessary control devices to accomplish each sequence, except as may be prohibited by the BAS Provider. The desired sequence shall be adjustable according to space usage or a change in space conditions.

E. Pressure and Leakage Certification
1. Manufacturer shall certify that each unit used on the Project will perform as specified. Each unit shall bear a tag or decal listing the following specified information:

a. Test pressure.
b. Leakage CFM (damper).
c. Leakage CFM (casing except fan-powered units).
d. Date of manufacture.

2.4 SINGLE DUCT VARIABLE VOLUME TERMINAL UNIT

A. Pressure independent, single duct variable or constant air volume control assemblies with integral attenuator, of the sizes, capacities and configurations as scheduled on the Drawings.

B. Unit pressure drop across the assembly with an equivalent 2000 fpm inlet velocity through the inlet shall not exceed 0.15 inches water gauge.

C. Sound Ratings: All sound power levels shall be obtained from testing in accordance with ARI Standard 880.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer's published recommendations.

C. Provide ceiling access doors or locate units above easily removable ceiling components.

D. Install terminal units with a minimum of four (4) diameters of straight duct directly prior to the entry into each terminal unit connection.

E. Connect to ductwork in accordance with Section 233100.

F. Wiring and controller compartments, electronic motors and damper motors shall have a minimum 24 inch clear wide and deep working space readily accessible from lift out ceiling tiles or access panels.

**END OF SECTION**

**SECTION 233700**

**AIR INLETS AND OUTLETS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the air inlets and outlets indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section:

C. Grilles, Registers and Diffusers

D. Linear Diffusers

E. Louvers

1.2 REFERENCES

A. Equipment and Installation shall meet the requirements outlined in the following references:

B. ACGIH: American Conference of Governmental Industrial Hygienists

C. AMCA: Air Movement and Control Association

D. NFPA: National Fire Protection Association

E. SMACNA: Sheet Metal and Air Conditioning Contractors National Association, Inc.

F. UL: Underwriters Laboratories, Inc.

G. AMCA 500 – Test Method for Louvers, Dampers and Shutters

H. ANSI/NFPA 90A – Installation of Air Conditioning and Ventilating Systems

I. ASHRAE 70 – Method of Testing for Rating the Air Flow Performance of Outlets and Inlets

1.3 SUBMITTALS

A. Product Data: (For Each Product)

B. Catalog cut-sheets

C. Indicate materials of construction, finish and mounting details

D. Mounting details

E. Installation instructions

F. Performance data (at actual operating conditions)

G. Throw and drop

H. Static-pressure drop

I. Noise ratings

J. Inlet and Outlet Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

K. Submit color and finish samples for all louvers.

L. Samples: When directed, submit one (1) complete unit for each type of proposed air inlet and outlet device. Approved samples will be delivered to the job site for installation.

## 1.4 QUALITY ASSURANCE

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Grilles, registers and diffusers shall be as scheduled on the Drawings. Grilles, registers and diffusers shall be provided with sponge rubber or soft felt gaskets where noted on the Drawings. Grilles, slot diffusers and laminar flow bars shall not be internally insulated.

C. If a manufacturer other than the one scheduled is used, the sizes shown on the Drawings shall be checked for performance, noise level, face velocity, throw, pressure drop, etc., before the submittal is made. Selections shall meet the manufacturer's own published data for the above performance criteria. The throw shall be such that the velocity at the end of the throw in the five (5) foot occupancy zone will not exceed 50 fpm or be less than 25 fpm except where indicated otherwise. Noise levels shall not exceed those published in ASHRAE for the type of space being served (NC level).

D. Locations of air distribution devices on Drawings are approximate and shall be coordinated with other trades to make symmetrical patterns and shall be influenced by the established general pattern of the lighting fixtures or architectural reflected ceiling plan, but primarily located to maintain proper air distribution. Where called for on Drawings, grilles, registers and diffusers shall be provided with deflecting devices and manual dampers. These grilles, registers, and diffusers shall be the standard product of the manufacturer, and subject to review by the Architect.

E. Provide a frame compatible with the type of ceiling or wall in which the devices are installed. Refer to Architectural Drawings for exact type of ceiling specified.

F. Coordinate color and finish of the devices with the Architect.

## PART 2 - PRODUCTS

### 2.1 GRILLES, REGISTERS, AND DIFFUSERS

A. Acceptable Manufacturers

B. Anemostat

C. Carnes

D. Krueger

E. Nailor

F. Price

G. Titus

H. Tuttle & Baily

I. Square Panel Face diffuser – Supply and Return

J. Architectural diffuser with a square panel face, centered within a square housing. The exposed surface of the face panel shall be smooth, flat and free of visible fasteners.

K. The diffuser shall have a 22-gauge steel face panel that captures a secondary 22-gauge panel. The panel shall project a maximum of 1/4" below the outside border of the diffuser.

L. For area of high moisture content or requiring non-ferrous materials, the diffuser shall be constructed of 22-gauge aluminum. This includes a 22-gauge aluminum panel that captures a secondary panel.

M. The face panel size shall be a minimum of 18” x 18” for 24” x 24” diffusers and 9” x 9” for 12” x 12” diffusers.

N. Registers and Grilles – Supply basis of design is titus 300 / 350 series

O. Aluminum or Steel, as scheduled.

P. 1 1/4" wide borders to have a minimum of thickness of 0.032” for sizes under 24” x 24”. Larger sizes shall be constructed of 0.040” or thicker material.

Q. Screw holes to be used for mounting, shall be countersunk.

R. Blades shall be spaced on 3/4" centers.

S. Opposed blade damper with removable key operator, operable from face, shall only be provided with registers or as noted on the Drawings.

T. Registers and Grilles – Return and Exhaust

U. Aluminum or Steel, as scheduled.

V. 1 1/4" wide borders to have a minimum thickness of 0.032” for sizes under 24” x 24”. Larger sizes shall be constructed of 0.040” or thicker material.

W. Screw holes to be used for mounting, shall be countersunk.

X. Blades shall be spaced on 3/4" centers.

Y. Opposed blade damper with removable key operator, operable from face shall only be provided with registers or as noted on the Drawings.

Z. Linear Slot Diffusers – General Requirements

AA. Continuous linear flow bar slot with adjustable vanes for left, right, or vertical discharge, with volume control. Provide slot width, length and number of slots as scheduled on the Drawings.

BB. Fabricate of aluminum extrusions with factory baked enamel finish.

CC. Provide support clips and gasket as required for ceiling system.

DD. Provide alignment strips for hairline joints and end caps where the slot terminates. Provide mitered corners.

EE. Provide black matte finish for all interior exposed-to-view components.

FF. Provide internally or externally (as noted in the drawings), factory-insulated supply air plenum. Insulated plenum shall be by the diffuser manufacturer. Insulation shall be UL 181 Class 1.

GG. Provide return slot diffuser same as supply, except without the adjustable vane control. Provide return air plenum for ducted return where indicated on Drawings.

HH. Provide with concealed fasteners.

II. Linear Slot Diffusers and Plenum basis of design is titus ml series with mp series modular plenums

JJ. Provide diffusers with number of slots, slot width and length as noted on the Drawings.

KK. Diffusers available as one (1) piece lengths up to 6 ft and from one (1) to eight (8) slots.

LL. The pattern controller to be an aerodynamically curved “ice-tong” configuration, capable of 180° pattern adjustment. Maximum pattern controller length to be 3’. If the diffuser is longer than 3’, multiple pattern controllers will be used.

MM. Units shall be constructed of 24-gauge steel.

NN. Provide unit with insulated galvanized sheet metal plenums as noted on the Drawings. Inlets shall have a minimum of 1 1/2” depth for duct connection. Inlet connection to be round or flat oval. Contractor shall provide a sheet metal flat oval-to-round transition as required for a sealed connection to the inlet flex duct or spiral branch ductwork.

OO. Provide diffuser with all necessary mounting accessories and borders to match the ceiling or wall where the diffusers shall be installed. Unit is capable of installation in lay-in or hard ceiling as well as sidewall applications.

PP. Linear Bar Diffusers

QQ. Streamlined blades with 0 to 15° deflection, as scheduled, 1/8” x 3/4" or 1/4" centers.

RR. Fabricate of aluminum extrusions, with factory clear anodized finish.

SS. Fabricate 1/2" margin frame with concealed mounting and gasket.

TT. Provide concealed fastening, straightening grids and alignment bars.

UU. Provide externally insulated plenums by diffuser manufacturer.

VV. Provide return bar diffusers same as supply with return air plenum.

WW. Silhouette finish.

## 2.2 LOUVERS

A. Acceptable Manufacturers

B. American Warming and Ventilating

C. Anemostat

D. Arrow

E. Greenheck

F. Pottorff

G. Ruskin

H. Tamco

I. United Enertech

J. Performance

K. Pass 750 feet per minute free velocity with less than 0.10” of water pressure drop, based in accordance with AMCA 500

L. Water penetration less than 0.025 ounce of water per foot of free area at 900 feet per minute

M. Provide a minimum of 45% free area

N. Frame

O. Material: Extruded aluminum, Alloy 6063-T5

P. Wall Thickness: 0.081 inch, nominal

Q. Depth: 6 inches

R. Furnish with exterior angle flange for installation

S. Blades

T. Depth: 6 inches

U. Style: Drainable

V. Material: Extruded aluminum, Alloy 6063-T5

W. Wall Thickness: 0.081 inch, nominal

X. Angle: 37.5 or 45 degrees, see schedule.

Y. Centers: 6 inches, nominal

Z. Bird Screen

AA. Material (intake): Aluminum, 3/4” x 0.051”, expanded

BB. Material (exhaust): Aluminum, 1/2" mesh x 0.063”

CC. Frame: Removable, rewireable

DD. Construction

EE. All welded construction

FF. Drain gutter in head frame and each blade

GG. Downspouts in jambs to drain water from louver for minimum water to cascade from blade to blade

HH. Accessories

II. Blank-off panels: 1", aluminum skin, insulated core, factory installed with removable screws and neoprene gaskets.

JJ. Hinged frame: Continuous piano hinge attached to angle or channel subframe

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

B. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

C. All installation shall be in accordance with manufacturer's published recommendations.

D. Diffusers

E. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, reflected ceiling plans, symmetry, and lighting arrangement.

F. Install air outlets and inlets to ductwork with airtight connection.

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

H. Provide all specialties and frames for air distribution devices as required for proper installation in ceiling type as indicated on Architectural Drawings. Provide all cutting and patching of T-bars, gypsum board, and other ceiling systems as required for installation of air devices.

I. Special Requirements

J. Paint ductwork visible behind air outlets and inlets matte black. Refer to Division 09.

**END OF SECTION**

**SECTION 235400**

**CONDENSING FURNACES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following equipment indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section:
1. Gas-fired condensing furnaces and accessories
2. Concentric vent and air intake termination kit
3. Roof termination flashing kit
4. Temperature Controls Thermostats
5. Air filters and frame assembly
6. DX Evaporator Coil Unit
7. Air Cooled Condensing Unit
8. Refrigeration line sets, components, and devices

1.2 REFERENCES

A. Metal Ductwork 233113

B. Air Inlets and Outlets 233700

C. Refrigerant Piping 232300

D. Ductwork Accessories 233300

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

F. ARI 210 Standard for Unitary Air Conditioning Equipment

G. US Department of Energy (DOE)

H. Gas Appliance Manufacturers Association (GAMA)

I. National Fire Protection Association (NFPA)

1.3 SUBMITTALS

A. Product Data is to indicate:
1. Manufacturer, model number, series number, and size clearly marked.

2. Rated capacities, operating characteristics, furnished specialties, and accessories.
3. Performance ratings for heating, cooling, fan airflows at various static pressures
4. Provide for all items of Scope included.

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.
2. Equipment, piping and connections, together with valves, strainers, control assemblies, thermostatic controls, auxiliaries and hardware and recommended ancillaries which are mounted, wired and piped ready for final connection to building system, its size and recommended bypass connections.
3. Piping, valves and fittings shipped loose showing final location in assembly.
4. Control equipment shipped loose, showing final location in assembly.
5. Field wiring diagrams.
6. Dimensions, internal and external construction details, installation clearances recommended method of installation, sizes and location of mounting bolt holes.
7. Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories, controllers.

C. Operation and Maintenance Data: Include in emergency, operation, and maintenance manuals for each of the following:
1. Furnace and accessories
2. Concentric vent and air intake termination kit
3. Temperature Controls Thermostats
4. Air filters.
5. DX Evaporator Coil Unit
6. Air Cooled Condensing Unit
7. Refrigeration line sets, components, and devices

## 1.4 QUALITY ASSURANCE

A. Qualifications
1. Installer experienced in performing work of this section who has specialized in installation of work similar to that required for this project.
2. Manufacturer Qualifications: Manufacturer capable of providing field service representation during construction and approving application method.

B. Pre-installation Meetings: Conduct pre-installation meeting to verify project requirements, manufacturer’s installation instructions and manufacturer’s warranty requirements. Comply with Division 1 Project Management and Coordination (Project Meetings.)

C. Warranty: Special warranty specified in this Section.

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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

F. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

G. Comply with NFPA 70.

## 1.5 COORDINATION

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

B. Coordinate installation of concentric termination kits, curbs, supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

## 1.6 WARRANTY

A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period, commencing on Date of Substantial Completion:
   1. Furnace Heat Exchanger: ten (10) years.
   2. Integrated Ignition and Blower Control Circuit Board: one (1) year.
   3. Draft-Inducer Motor: one (1) year
   4. Refrigeration Compressors: five (5) years.
   5. Evaporator and Condenser Coils: one (1) year.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. General: Comply with Division 1 Product Requirements.

B. Ordering: Comply with manufacturer’s ordering instructions and lead time requirements to avoid construction delays.

C. Packing, Shipping, Handling and Delivery:
   1. Deliver materials in manufacturer’s original, unopened, undamaged containers with identification labels intact.
   2. Ship, handle and unload units according to manufacturer’s instructions.

D. Storage and Protection
   1. Store materials protected from exposure to harmful weather conditions.
   2. Factory shipping covers to remain in place until installation.

PART 2 - PRODUCTS

2.1 GAS-FIRED FURNACES, CONDENSING

A. Acceptable Manufacturers
   1. Trane or preapproved equal

B. Performance
   1. See scheduled performance values and model information on drawings.
   2. Minimum rated AFUE: 97%.

C. General Requirements for Gas-Fired, Condensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3, "Gas-Fired Central Furnaces," and with NFPA 54.

D. Cabinet
   1. Up flow air delivery or horizontal air delivery, as noted on the Drawings.
   2. Sealed combustion, direct vent.
   3. Heavy Gauge cold-rolled steel
   4. Adjustable locations for flue outlet and air inlet
   5. Gas piping inlets and electrical inlets on both sides
   6. Complete service access from the front of the unit
   7. Cabinet interior around heat exchanger shall be factory-installed foil-faced insulation.
   8. Flanges on exterior of supply air opening for duct connection.
   9. Gasketed blower compartment.
   10. Lift-out panels shall expose burners and all other items requiring access for maintenance.
   11. Safety interlock switch to automatically shut off power to unit when blower compartment access door is removed.
   12. Factory pre-painted external cabinets in manufacturer's standard color.

E. Fan
   1. Centrifugal, direct drive
   2. Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
   3. Factory statically and dynamically balanced, resilient mounted.
   4. Assembly easily removable for servicing.
   5. Speeds easily changed on integrated furnace control board.
   6. Fan Motors: Comply with requirements in Division 15 Section 15170 Motors.

F. Type of fuel: Natural gas

G. Heat Exchanger
   1. Primary: Heavy gauge aluminized steel, 3-pass crimped seam, clamshell design. Designed for normal expansion and contraction with maximum efficiency and minimum resistance to air flow.
   2. Secondary: Condenser coil constructed of aluminum fins fitted to stainless steel tubes, factory tested for leaks.
   3. Condensate drain header box assembly located on front of secondary heat exchanger coil.

4. All components mounted in heavy-gauge steel frame.
5. Entire heat exchanger assembly laboratory life-cycle tested.

H. Burner
1. Aluminized steel
2. Assembly removable as single component from unit
3. Gas Valve: 100 percent safety, two-stage, 24 volt main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
4. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
5. Redundant combination, dual gas valves.
6. Compact control to contain manual shutoff, automatic electric valves, and gas pressure regulation.

I. Gas-Burner Safety Controls
1. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
2. Flame Rollout Switch: Factory installed on burner box, prevents burner operation, with manual reset.
3. Limit Control:
   a. Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
   b. Primary limit and Secondary limit required.

J. Combustion-Air Inducer: Two (2)-speed centrifugal fan with thermally protected motor and sleeve bearings pre-purges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.

K. Furnace Controls
1. Solid-state board integrates ignition, heat, cooling, and fan speed; adjustable fan-on and fan-off timing; terminals for connection to accessories diagnostic light with viewport.
2. Solid-state furnace control board containing all necessary controls and relays to operate furnace.
3. Ignition control LED’s to indicate status and aid in troubleshooting.
4. Field wiring makeup boxes.
5. 24 volt transformer, factory installed.

L. Accessories
1. Combination Combustion-Air Intake and Vent: Concentric PVC plastic fitting to combine combustion-air inlet and vent through roof or sidewall as shown on Drawings. Provide roof flashing kit as required. Coordinate with General Contractor and roofing manufacturer.
2. PVC Plastic Vent Materials:
   a. PVC Plastic Pipe: Schedule 40, complying with ASTM D 1785.
   b. PVC Plastic Fittings: Schedule 40, complying with ASTM D 2466, socket type.
   c. PVC Solvent Cement: ASTM D 2564.
3. Condensate Collection:
   a. Header box on end of secondary heat exchanger collects flue gas condensate for disposal through condensate collars. Hose connects header box drains to the condensate collars.

b. Condensate collars on each side of cabinet for field installation of condensate trap. Active collar is used, other one to be plugged.
c. Flue condensate trap assembly mounted outside the conditioned air stream.

## 2.2 THERMOSTATS

A. Manufacturers: Matching condensing furnace manufacturer

B. Solid-State Thermostat
1. Wall-mounted, programmable, microprocessor-based unit with automatic switching from heating to cooling, preferential rate control.
2. Seven-day programmability with minimum of four temperature presets per day, vacation mode, and battery backup protection against power failure for program settings.
3. Thermostat to engage 1st stage of heating or cooling initially, followed by 2nd stage, with adjustable dead-band and time duration parameters.
4. Controls to modulate fan speed to in conjunction with stages of heating/cooling to maintain space temperature setpoint.

C. Control Wiring
1. Unshielded twisted-pair cabling.
2. Plenum rated cabling, meeting 25/50 Fire/Smoke rating.
3. Minimum of no. 24 AWG, 100 ohm, four pair.
4. Cable Jacket Color: blue

D. Controls shall comply with requirements in ASHRAE/IESNA 90.1-2004, "Controls."

## 2.3 AIR FILTERS AND FRAME

A. Manufacturers: As provided by condensing furnace manufacturer.

B. Disposable Filters: Pleated 2” thick fiberglass media with ASHRAE 52.2 MERV rating of 6 or higher.

C. Side filter rack kit:
1. Frame size to accommodate nominal 24”x25”x2” air filters, interior guide rails to accept filters by sliding in from front.
2. Sheet metal frame to connect to furnace return air intake flange at side of furnace cabinet.
3. With hasped and hinged access door, gasketed full perimeter of door.

## 2.4 REFRIGERATION COMPONENTS

A. Manufacturers: Matching condensing furnace manufacturer.

B. General Refrigeration Component Requirements:
1. Refrigeration compressor coils, and specialties shall be designed to operate with CFC-free refrigerants.

2. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."

C. Refrigerant DX Evaporator Coil
1. Copper tubes mechanically expanded into aluminum fins. Comply with ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment." Match size with furnace.
2. Include condensate drain pan with accessible drain outlet complying with ASHRAE 62.1-2004. Pitch drain pans in two (2) directions towards the outlet, with a slope of at least 1/8" per foot.
3. Provide factory installed thermostatic expansion valve and refrigerant leak detection system.
4. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.

D. Refrigerant Line Kits
1. Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated.
2. Provide in standard lengths for installation without joints, except at equipment connections.
3. Suction line insulation: Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I, 1" thick.

E. Air-Cooled Refrigerant Compressor Condensing Unit
1. Casing:
   a. Steel, finished with baked enamel, with removable panels for access to controls,
   b. Weep holes for water drainage, and mounting holes in base.
   c. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor:
   a. Hermetically-sealed, two-speed scroll type, resiliently mounted integral with condenser.
   b. Crankcase heater, with positive lubrication.
   c. Vibration isolation mounts for compressor.
   d. Compressor motor shall have thermal and current-sensitive overload devices, start capacitor, relay, and contactor.
   e. High pressure control, hard start kit, motor thermal overload protection, service valves, and drier.
   f. Variable-speed compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
   g. Refrigerant: R-454B.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid sub-cooler.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45° F.

F. Performance Capacities and Characteristics
   1. See scheduled values on drawings for refrigerant evaporator coil and air-cooled condensing unit performance and operation conditions required.

## 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. Verify substrate conditions, which have been previously installed under other sections, are acceptable for product installation in accordance with manufacturer's instructions

C. Examine factory-installed insulation before furnace installation. Reject units that are wet, moisture damaged, or mold damaged.

D. Examine roughing-in for gas and refrigerant piping systems to verify actual locations of piping connections before equipment installation.

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

### 3.2 INSTALLATION

A. Install gas-fired furnaces and associated fuel and vent features and systems according to NFPA 54.

B. Install Furnaces accordance with manufacturers' instructions and regulations of authorities having jurisdiction

C. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.

D. Controls: Install thermostats at mounting height of 60 inches above floor.

E. Wiring Method: Install control wiring in accessible ceiling spaces and in conduit inside masonry unit walls or gypsum board partitions. Stub conduit out above wall with burr-free elbow. Conceal control wiring except in unfinished spaces.

F. Install ground-mounted, compressor-condenser components on reinforced concrete base. Use minimum 3000 PSF concrete, or similar spec grade to that for building foundation. Coordinate pad location and elevation with General Contractor. Coordinate anchor installation with concrete base. See drawings for pad sizes and reinforcing required.

## 3.3 CONNECTIONS

A. Gas piping installation requirements are specified in Division 23 Section titled Natural Gas Piping. Drawings indicate general arrangement of piping, fittings, and specialties. Connect gas piping with union or flange and appliance connector valve.

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

C. Vent and Outside-Air Connection, Condensing, Gas-Fired Furnaces: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a concentric termination kit and in an arrangement that will protect against entry of birds, insects, and dirt.
   1. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
      a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
      b. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   2. Slope pipe vent back to furnace or to outside terminal.

D. Connect ducts to furnace with flexible connector. Comply with requirements in Division 23 Section "Ductwork Accessories."

E. Connect refrigerant tubing kits to refrigerant coil in furnace and to air-cooled, compressor-condenser unit.

F. Comply with manufacturer’s requirements for field installation and joint construction of refrigerant piping line kits.

G. Pipe cooling coil and flue vent condensate drains from unit to floor drain full size. Provide P-trap for cooling coil condensate, min. 3” trap depth. Provide removable couplings or unions for easy disassemble for cleaning and service.

## 3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Perform electrical test and visual and mechanical inspection.
   2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
   4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
   5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Verify that vibration isolation and flexible connections properly dampen vibration transmission.

## 3.5 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and perform the following
   1. Inspect for physical damage to unit casings.
   2. Verify that access doors move freely and are weathertight.
   3. Clean units and inspect for construction debris.
   4. Verify that all bolts and screws are tight.
   5. Adjust vibration isolation and flexible connections.
   6. Verify that controls are connected and operational.

B. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.

C. Measure and record airflows.

D. Verify proper operation of capacity control device.

## 3.6 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including balancing dampers, bandwith and deadband of space temperature, and controls to provide optimum heating performance and system efficiency.

## 3.7 CLEANING

A. After completing installation, clean furnaces internally according to manufacturer's written instructions.

B. Install new filters in each furnace within fourteen (14) days after Substantial Completion.

## 3.8 DEMONSTRATION

A. Train owner's maintenance personnel to adjust, operate, and maintain condensing units. Refer to Division 01 Section "Demonstration and Training" and Division 23 Section 230500.

**END OF SECTION**

**SECTION 236213**

**PACKAGED CONDENSING UNITS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following condensing units indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
1. Air-cooled condensing unit shall consist of hermetic scroll compressor component utilizing R-454B.
2. Air-cooled condenser coil
3. Condenser fans
4. Vibration isolation assemblies
5. Microprocessor control center.

1.2 REFERENCES

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
1. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. ARI 410 - Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
3. ANSI/ASHRAE 15 - Safety Standard for Refrigeration Systems.
4. ASHRAE 90.1 - Energy Standard for Buildings Except Low High Rise Residential Buildings.
5. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
6. ASHRAE 23 Methods of Testing for Rating Positive Displacement Condensing Units.

1.3 SUBMITTALS

A. Provide literature that indicates
1. Dimensions, weight, loading, clearances, capacities, gauges, thickness, and finishes of materials, electrical characteristics and connections
2. Rigging, installation, testing, Start-up and operating instructions, maintenance data including type and quantity of oil and refrigerant change (pounds), parts lists, and troubleshooting guide

3. Information about control and wiring diagrams
4. Refrigerant piping diagram and isometric
5. Product test data on sound power levels at the rated design capacity
6. Operating data such as fans speeds, compressor LRA and RA, sound levels
7. Product data on all condenser fan accessories such as controls

## 1.4 QUALITY ASSURANCE

A. The design of the unit shall be AGA and ARI certified as combination heating-cooling units for rooftop installation.

B. Unit construction shall comply with ASHRAE 15 safety code, NEC, and UL applicable codes.

C. Cooling capacity ratings shall be in accordance with ARI standard 210/240, most recent edition.

D. Insulation and adhesive shall meet NFPA 90A requirements.

## 1.5 WARRANTY

A. Units shall be furnished with full coverage warranty against defects in materials. Warranty on the complete unit shall be for one (1) year from the Substantial Completion date. On the compressors, warranty shall be for five (5) years from the Substantial Completion date.

# PART 2 - PRODUCTS

## 2.1 AIR COOLED CONDENSING UNITS (7 to 100 tons)

A. Acceptable Manufacturers
   1. Trane or preapproved equal

B. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

C. Description: Factory assembled and tested, consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.
   1. Compressor: Scroll, hermetically sealed, with rubber vibration isolators
      a. Motor: includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor
      b. Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch
      c. Accumulator: Suction tube
   2. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.
   3. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings.

D. Accessories
   1. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
   2. Electronic programmable thermostat to control condensing unit and evaporator fan.
   3. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
   4. Filter-dryer.
   5. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
   6. Liquid-line solenoid
   7. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure
   8. Thermostatic expansion valve
   9. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off

E. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gauge ports on exterior of casing.

F. Unit efficiency shall be in compliance with the requirements of the International Energy Conservation Code AHSRAE 90.

G. Integral Unit Controls: As a minimum, the packaged unit's components shall be protected with high pressure-stat, loss-of-charge protection, current and temperature sensitive overload devices, and anti-short cycle timer control circuit to prevent the compressor from restarting for five (5) minutes after stopping.

H. Timer to prevent short cycling – five (5) minute delay (adj.)

I. High- and low-refrigerant-pressure safety controls

J. Power- and control-circuit terminal blocks

K. Compressor motor starter

L. Control-circuit on-off switch

M. Control-circuit fuse

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer's published recommendations.

C. Power wiring to the units, including externally mounted service disconnect switch, shall be furnished and installed under Division 26.

D. Installing Contractor shall be provided with the manufacturer's Shop Drawings as required for power wiring installation.

3.2 TESTING

A. Install the unit level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
   1. Install condensing units on concrete base.
      a. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of the base.
      b. For equipment supported on structural slab, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      d. Install anchor bolts to elevations required for proper attachment to supported equipment.
      e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.3 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Inspect for physical damage to unit casing.
   2. Verify that access doors move freely and are weathertight.
   3. Clean units and inspect for construction debris.
   4. Verify that all bolts and screws are tight.
   5. Adjust vibration isolation and flexible connections.
   6. Verify that controls are connected and operational.

B. Lubricate bearings on fans.

C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.

D. Adjust fan belts to proper alignment and tension.

E. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.

F. Verify proper operation of condenser capacity control device.

G. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

**END OF SECTION**

**SECTION 237313**

**MODULAR AIR HANDLING UNITS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the modular air handling units indicated by the Contract Documents with supplementary items necessary for proper installation

B. Equipment included in this section:
1. Return Fan
2. Relief Air Section
3. Filter / Mixing Box
4. Heating Coil
5. Cooling Coil
6. Supply Fan
7. Access Sections

1.2 REFERENCES

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
1. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
3. AMCA 99 - Standards Handbook.
4. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
5. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
6. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.
7. AMCA 500 - Test Methods for Louver, Dampers, and Shutters.
8. ARI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment
9. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
10. ARI 430 - Central-Station Air-Handling Units.
11. ARI 610 - Central System Humidifiers.
12. NEMA MG1 - Motors and Generators.
13. NFPA 70 - National Electrical Code.
14. NFPA 90A – Flame and Smoke Spread Ratings.
15. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
16. UL 900 - Test Performance of Air Filter Units.

17. ANSI/ASHRAE/IESNA Standard 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings

## 1.3 SUBMITTALS

A. Product Data and Record Documents
   1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gauges and finishes of materials, electrical characteristics and connection requirements. Refer to detailed listing of submittal data in this Section.
   2. Provide data of filter media, filter performance data, filter assembly, and filter frames as tested and certified per ASHRAE standards and NFPA 90 flame spread and smoke rating standards.
   3. Provide fan curves with specified operating point clearly plotted, as tested and certified per AMCA standards. Ratings to include system effects. Bare fan ratings will not satisfy this requirement, but shall be submitted for comparison purposes. All fan data shall be generated from specified testing. The fan shall compare favorably with the scheduled data listed in the Drawings. Where two fans are operated in parallel, provide Hagen's Line plots on fan curves to prove that fans will not be operating in the unstable region.
   4. Submit sound power level data for both fan outlet and casing radiation at rated capacity, as tested and certified per AMCA and ARI 260 standards. All fan data shall be generated from specified testing. The fan shall compare favorably with the scheduled data listed in the construction Drawings. The selected unit will not exceed the scheduled sound power data.
   5. Provide data on all coils as tested and certified per ARI standards.
   6. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
   7. All materials shall have NFPA-90 rating of 25/50 or better.
   8. Base Rail Height Calculations: Provide calculations for required base rail heights to allow for proper condensate trapping per condensate drain details.

B. Operation and Maintenance Data
   1. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
   2. Provide Operating and Maintenance (O&M) Manuals for air handling units. In addition to a full set of manuals with closeout documentation, each unit shall ship with its own manual permanently mounted inside the unit casing fan section in a watertight enclosure.
   3. Permanently mount condensate trapping calculation instructions within the unit O&M Manual that illustrates the unit casing at the condensate drain connection.
   4. Manufacturer's Instructions: Provide Start-up information and maintenance required prior to Start-up.

## 1.4 QUALITY ASSURANCE

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction. Performance Ratings: Conform to ARI Standards; bear ARI 430 certified rating seal. If unit is

not ARI 430 rated, unit shall be tested in accordance with the standards to establish acceptability.

B. Sound Ratings: Test air handling unit in accordance with AMCA 300 (ASHRAE 68) and ARI 260 Guidelines.

C. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410.

D. Manufacturer: Regularly engaged in production of components that issues complete catalog data on total product and has at least two (2) years of manufacturing experience for the product specified.

E. Base performance on sea level conditions, unless otherwise scheduled.

F. Provide complete unit including components designed to operate within range of 35° F to 135° F ambient temperature, 20 to 70 percent relative humidity in conditioned mechanical rooms and 100 percent relative humidity in unconditioned mechanical rooms.

G. The Contract Documents are based on the equipment scheduled. Contractor is advised that the use of equipment other than that scheduled may directly affect and require coordination with (but not limited to) the following items:
   1. Mechanical room sizes and building structural conditions, with required clearances.
   2. Electrical starter/disconnect switch, wire and conduit sizes; electrical clearances as per NEC.
   3. Ductwork and piping layouts and return air opening sizes and locations.
   4. Plumbing floor drain location.
   5. Units shall fit into the space available with adequate clearance for service as determined by the Engineer. Submitted units, which do not meet these criteria, shall be rejected. Do not assume that all of the manufacturers listed as acceptable manufacturers will provide a unit that will fit in the space allocated. Selection of acceptable manufacturers is not based on whether the manufacturer's standard stock unit will fit into every space allocated. A custom or semi-custom air-handling unit may be required to meet project space and performance requirements.

## 1.5 DELIVERY, STORAGE AND HANDLING

A. Accept products on Site in factory-fabricated protective containers or covered to protect from weather and construction debris, with factory-installed shipping skids and lifting lugs. Inspect for damage and make any necessary repairs at no expense to the Owner.

B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish. Replace damaged equipment.

C. Protect openings in casing and seal them with plastic wrap to keep dirt and debris, also protect coils from entry of dirt and debris with pipe caps or plugs.

1.6 EXTRA MATERIALS

A. Provide one (1) additional sets of specified fan belts, sheaves, and filters for each unit, packaged for storage after each unit has been tested and operated for final acceptance by Owner. Tag products to identify associated unit.

1.7 WARRANTY

A. Units shall be furnished with full coverage warranty against defects in materials. Warranty on the complete unit shall be for one (1) year from the Substantial Completion date.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Trane – Climate Changer or preapproved equal

2.2 GENERAL REQUIREMENTS

A. All air handling units shall be a draw-through configuration type unless noted otherwise (as scheduled) double-wall air-handling unit meeting or exceeding the performance requirements and capacities as shown.

B. All internal components specified shall be factory furnished and installed. Units shall be post and panel bolted modular and sectionalized construction for ease of disassembly and reassembly for maintenance, cleaning, and inspection in accordance with the most recent edition of ASHRAE Standard 62. At a minimum, sectionalized modules shall consist of fan, coils, access and filter sections. All internal components specified shall be factory furnished and installed as applicable.

C. Provide all necessary and required tags and decals to aid in the service or indicate caution areas.

D. Ship unit in one (1) piece whenever possible. If shipping splits are required for installation, the unit must be assembled with all required gasketing under direct supervision of factory trained and employed personnel from the unit manufacturer. Written approval from the equipment manufacturer certifying the installing mechanical contractor as qualified for assembly is acceptable as an alternative for supervision. The equipment manufacturer, however, shall not relinquish its responsibility for the correct assembly of units.

E. Provide complete unit with segments as indicated on drawings and in this specification or as required for unit operation in accordance with performance requirements specified herein. Refer to filter specification section for filter requirements.

## 2.3 CASING WALLS

A. Provide post and panel construction with unit casing walls of minimum 16 gauge or equivalent exterior and 20 gauge solid interior G90 galvanized steel panels for all sections. Casing to be two inch double wall foam.

B. Casing walls shall be non-load bearing and must allow air handling unit interior cleaning of microbial growth and other debris per the latest ASHRAE Standard 62.

C. Provide gaskets between section and access panels. All panels shall be sealed to create an airtight unit. Assemble sections with gaskets and bolts. Sheet metal screws are not acceptable as use as panel or frame fasteners. Reinforce and brace unit housing with steel angle framework to provide rigidity and prevent pulsations. Provide thermal breaks between inner and outer walls and posts to prevent moisture condensation on the exterior of the unit. Any condensation on the units shall be corrected to the satisfaction of the Owner and at no expense to the Owner.

D. The manufacturer shall certify that the unit casing leakage shall not exceed 0.5 cfm per square foot of cabinet area at 5 inches positive or negative static pressure. Panel deflection shall not exceed L/240 ratio at a maximum 5 inches of positive or negative static pressure. Deflection shall be measured at the midpoint of L, which is the panel height.

## 2.4 INSULATION

A. Provide factory insulated casing sections with expanded foam or non-compressed fiberglass (three pound per cubic foot density) insulation with a minimum R-value of 12.

B. Insulation and adhesive shall meet requirements of NFPA 90A. Insulation shall meet the erosion requirements of UL181.

C. No insulation surfaces shall be exposed to the airstream. Install insulation in manner to not be disturbed when panels are removed.

## 2.5 ACCESS/INSPECTION DOORS

A. Provide galvanized steel double wall inspection doors of the same thickness and construction as the casing panels. Provide full-perimeter flush mounted and gasketed doors with a latch and handle assembly.

B. Provide heavy-duty cadmium plated steel or stainless steel hinges.

C. Hinges shall be interchangeable with the door handle hardware to allow for alternating door swing in the field to minimize access interference. Door handle hardware shall visually indicate locking position of door latch external to the module. Door latching hardware shall not penetrate the access doors.

D. All access doors shall open against air pressure, unless approved by the Owner in writing.

E. Dual thermal pane windows shall be provided in all access doors. Minimum window dimensions shall be 8-inch x 8-inch.

F. Provide access doors to access / maintain the following equipment:
   1. Fans
   2. Filters
   3. Coils
   4. Locations where specified on the Drawings.

## 2.6 INSPECTION AND ACCESS PANELS

A. Provide galvanized steel double wall inspection doors of the same thickness and construction as the casing panels. Provide full-perimeter flush mounted and gasketed doors with a camlock latch and handle assembly.

B. Fasteners: Two (2) or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.

C. Gasket: Neoprene, applied around entire perimeters of panel frames.

D. Size: Large enough to allow for inspection and maintenance of air-handling unit's internal components.

E. Dual thermal pane windows shall be provided in all access doors. Minimum window dimensions shall be 8-inch x 8-inch.

F. Provide access doors to access / maintain the following equipment:
   1. Fans
   2. Filters
   3. Coils
   4. Locations where specified on the Drawings.

## 2.7 COIL CASINGS

A. Construct coil section so coils can be removed without affecting structural integrity of casing. Completely enclose connections, coil headers, and return bends.

B. Provide Type 304 stainless steel coil frame with intermediate casing supports as required.

## 2.8 DRAIN PANS

A. Provide drain pans constructed of galvanized steel on airside with insulation between pan and casing. The drain pan insulation shall be closed cell foam injected water impervious rigid type, minimum R-value of eight (8), and shall occupy all voids and areas between the drain pan and outer wall to prevent the occurrence of trapped water, condensation, and microbial growth. Fiberglass drain pan insulation is not acceptable.

B. Any condensation from the drain pan or drain connection shall be corrected by unit manufacturer to the satisfaction of the Owner, and at no expense to the Owner.

C. Drain pan shall have raised lips, welded corners, and galvanized steel threaded pipe drain connection to match the drain pan and prevent dielectric corrosion.

D. Drain pan connections that penetrate the base rail must be a minimum of six (6) inches in height as described above, and shall come factory insulated in a permanent aluminum jacket to prevent condensation of moisture under the unit.

E. Drain pans must be triple sloped for complete drainage and in compliance with ASHRAE Standard 62. Unit condensate drain inlet shall be centered on bottom of drain pan to allow complete drainage. Provide drain pans extending under complete cooling coil section and extending 24 inches minimum downstream of cooling coil. Provide intermediate drain pans that extend minimum of six (6) inches from the coil face with downspouts to bottom drain pan for cooling coil banks more than one coil high. Intermediate drain pans shall be stainless steel to match the main drain pan.

F. Fabricated with one (1) or two (2) percent slope in at least two (2) planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.

G. Pan-Top Surface Coating: Asphaltic waterproofing compound.

H. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

## 2.9 FANS, DRIVES AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
   1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

B. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil

C. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

D. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet.
   1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

E. Horizontal-Flanged, Split Housing: Bolted construction.

F. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.

G. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches **or** 5-3/4 inches wide attached to two (2) strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized-steel sheet or 0.032-inch- thick aluminum sheets; select metal compatible with casing

H. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

I. Fabric Minimum Weight: 26 oz./sq. yd.

J. Fabric Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.

K. Fabric Service Temperature: Minus 40 to plus 200° F.

L. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.

M. Fan Wheels
1. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
2. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
3. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

N. Fan Shaft Bearings
1. Pre-lubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of 250,000 hours according to ABMA 9.
2. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two (2)-piece, cast-iron housing with grease lines extended to outside unit and a rated life of 250,000 hours according to ABMA 11.
3. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two (2)-piece, cast-iron housing with grease lines extended to outside unit.

O. Adjustable pitch for use with five (5) hp motors and smaller; fixed pitch for use with motors larger than five (5) hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

P. Discharge Dampers: Heavy-duty steel assembly with channel frame and sealed ball bearings, and opposed blades constructed of two (2) plates formed around and welded to shaft, with blades linked out of air stream to single control lever.

Q. Internal Vibration Isolation
1. Mount motor drive and fan on integral framework, internally isolated from the casing with factory installed 1-inch deflection spring vibration isolators on units with eight (8)

square feet of coil area or less, and two (2)-inch deflection on units with coils greater than eight (8) square feet in area. The fan, drive, and base assembly shall be factory point load tested and balanced with corner isolators selected accordingly for increased stability and to minimize fan assembly noise and vibration and extend bearing life.

2. Provide internal flexible connection on discharge of fan to isolate fan from casing. Additionally, provide spring loaded fan-shroud-to-casing thrust restraints for all airfoil and backward inclined fans, and on all units with coil face areas greater than thirty (30) square feet.
3. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 2 inches (50 mm).

R. Motors
1. Default motor characteristics are specified in Section 230513 – Motors.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

## 2.10 DX COILS

A. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.

B. Rate coils in accordance with ARI certified data. Select coil to provide capacity in accordance with water flow and temperatures scheduled on Drawings. Provide coil with maximum face velocity of 375 fpm for constant volume applications and 400 fpm for variable volume applications or as indicated otherwise on Drawings.

C. Provide 1/2-inch or 5/8-inch outside diameter copper tube coils, staggered in direction of airflow, with aluminum plate fins, maximum 6-row and nine (9) fins per inch with copper headers. Steel pipe water connections shall be welded to copper headers with silica-bronze weld to prevent dielectric corrosion of dissimilar metals and extend the life of the coils. If additional rows are required pipe coils in series and provide access section between coils.

D. Provide coils with plate fin wall thickness of 0.006-inch and tubes of minimum wall thickness of 0.035-inch for 5/8-inch coils and 0.020 for 1/2-inch coils. Connect tubes to header that provides equal flow to all tubes and provide single point connections for supply and return piping per coil. Factory test all coils to 325 psig and forward coil test reports to the Engineer with submittal documentation.

## 2.11 GAS HEATING COILS

A. Indirect Fired Gas Heater Coils, Controls, and Accessories: Comply with UL 795.

B. Heat exchanger shall be constructed of 409 stainless steel.

C. The furnace heat module shall be UL listed, induced draft, and fully modulating.

## 2.12 FILTERS

A. General
   1. Air shall not be allowed to bypass around filters. Provision shall be made to positively lock filters in place to prevent shifting.
   2. Provide applicable filter and final filter sections as scheduled or shown on the Drawings.
   3. Provide specified filters for use during construction and replace with new filters prior to testing and balancing. Replace filters as needed between testing and balancing, functional performance tests and final acceptance by Owner.
   4. Some units may have multiple filter sections and multiple filter types. Some filter section types shown here may not be used on the Project.

B. Angle Filters: Low-velocity angular filter frames with integral, side-access, galvanized steel or extruded aluminum filter frames suitable for 2-inch media. Combine with mixing box where scheduled on Drawings.

C. Flat Filters: Flat (perpendicular to airflow direction) filter frames with integral, side-access, galvanized steel or extruded aluminum filter frames suitable for 2-inch or 4-inch media (as scheduled).

D. Cartridge (Rigid) Filters: Flat (perpendicular to airflow direction) filter frames with integral, front or side-access, galvanized steel or extruded aluminum filter frames, with neoprene gasketing on the leaving air side of the filter, suitable for a 2-inch pre-filter media and a 12-inch rigid filter media.

E. Filter Gauges: Magnahelic differential pressure gauges shall be installed and mounted on drive side of unit to measure the pressure drop across all filter banks.

F. Refer to Division 23 Section “Filters” for filter requirements.

G. Refer to Drawings and unit schedules for quantity and type of filter media scheduled per unit.

## 2.13 ADDITIONAL SECTIONS

A. All additional sections of the unit, including blank sections and turning sections required for proper unit operation, maintenance, and configuration, shall meet the unit casing requirements listed in this Section. Refer to Drawings for additional sections required.

B. Mixing Box Section: Where specified or shown on the Drawings, provide with factory-mounted interconnected outside and return air dampers mounted in a galvanized frame. Mixing box section shall be configured to allow access to front-load filter frame.

C. Economizer Section: Where specified or shown on the Drawings, provide an economizer section complete with three sets of dampers to control return, exhaust and outside air.

D. Diffuser Section: Provide with perforated diffuser plate that assures an even distribution of airflow across the entire unit internal area. Units are specified with final filters or blow-through coils, shall have a diffuser section immediately downstream of the fan.

E. Access Section(s): Provide access sections with door where specified or shown on Drawings. Floors of access section must be heavy-duty to accommodate maintenance personnel/equipment. Door size shall be at least 18 inches wide and full panel height up to 72-inch tall units.

F. Discharge Plenum: Provide a discharge plenum as the last section in the direction of airflow where specified or shown on the Drawings. The plenum shall be suitable for single or multiple discharges as indicated on the Drawings. Positive pressure plenum access doors must swing inward against air pressure to prevent personnel injury.

## 2.14 DAMPERS

A. Provide ultra-low leakage opposed blade dampers furnished by the unit manufacturer with galvanized steel double-skin airfoil blades. Blades shall have vinyl or rubber blade edge seals and compressible jamb seals. Blades shall rotate on stainless steel sleeve bearings. Dampers must be constructed and tested so as to have a leakage rate not to exceed 5 cfm per square foot. at 1 w.g. differential pressure.

B. All dampers that will be in contact with outside air shall be insulated.

## 2.15 ELECTRICAL

A. Fan motors shall be factory mounted and wired to an external disconnect switch within sight of the motor access door. Fan motors shall be interlocked with fan access door to shut down fan when door is opened.

B. Disconnect switches and starters shall be mounted independent of the unit to allow for maintenance access and access to AHU components. Locate disconnect switches within close proximity and sight of the electrical component. Interlock fan motor starters with a position limit switch located at the fan section access door. The limit switch shall de-energize the fan motor or other electrical components when the access door is opened.

## 2.16 LIGHTS

A. Service Light: 100-W or LED equivalent vaporproof fixture inside the specified unit section with switched junction box located outside (indoors AHU’s) or inside (outside units) adjacent to door.

B. Conduit and power connections between switched junction boxes on respective AHU sections shall be field-connected by the Electrical Contractor.

C. Light Locations:
   1. Each section accessed with a door/panel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer's published recommendations.

C. Make joints and connections fully gasketed and air-tight.

D. Install filters.

E. All vibration isolator bolts used to restrain the equipment during shipping have been removed.

F. Install units on equipment supports as described in vibration isolation specification section.

G. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under Owner representatives' observation.

H. Casing Integrity
   1. No field penetrations of the air handler casing are permitted.
   2. All penetrations required to accomplish testing, balancing, to provide power to internal devices, and to provide control signals to and from control devices shall be made and sealed at the factory.
   3. Coordinate with the manufacturer to allow for all necessary penetrations to provide a complete, functioning, and maintainable system. Internal control devices shall be shipped to the air handler manufacturer for installation at no cost to the Owner.

**END OF SECTION**

**SECTION 238126**

**SPLIT SYSTEM AIR CONDITIONERS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the split system air conditioning units indicated by the Contract Documents with supplementary items necessary for proper installation

B. Equipment Included in This Section
   1. Split system air conditioner system with Variable Speed Inverter Compressor technology. The system shall consist of a horizontal discharge, single phase outdoor unit and a matched capacity indoor section that shall be equipped with a wired wall mounted and/or wireless handheld remote controller.

C. The indoor units shall be one (1) of the following configurations
   1. Wall-mounted
      a. 9,000 – 36,000 Btuh
      b. Minimum 14.0 SEER

1.2 REFERENCES

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1 (adopted version).

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For computer-room air conditioners. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

C. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

D. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from Installers of the items involved.

E. Field quality-control reports.

F. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

G. Warranty: Sample of special warranty.

## 1.4 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (N.E.C.) and local codes as required.

C. The units shall be rated in accordance with Air-conditioning, Heating, and Refrigeration Institute's (AHRI) Standard 210 and bear the ARI Certification label.

D. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

## 1.5 WARRANTY

A. The units shall have a manufacturer's parts and defects warranty for a period five (5) year from date of installation. The compressor shall have a warranty of seven (7) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty does not include labor.

## 1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One (1) set of filters for each unit.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

1. Daikin
2. Fujitsu
3. LG
4. Mitsubishi Electric
5. Panasonic
6. Samsung
7. Lennox

2.2 OUTDOOR UNITS - GENERAL

A. The outdoor unit shall be compatible with the four different types of indoor units as noted above. The connected indoor unit shall be of the same capacity as the outdoor unit.

B. The outdoor unit shall be equipped with a control board that interfaces with the indoor unit to perform all necessary operation functions.

C. Outdoor unit shall be capable of operating at 0° F ambient temperature without additional low ambient controls.

D. The outdoor unit shall be able to operate with a maximum height difference of 100 feet (30 meters) between indoor and outdoor units.

E. The system shall have the following maximum tubing length restrictions between indoor and outdoor units. Line size changes, traps or additional oil will not be required using these parameters.
   1. 9,000 – 18,000 Btuh: 100 feet
   2. 24,000 – 42,000 Btuh: 165 feet

F. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.

G. Outdoor unit sound level shall not exceed:

| Capacity | Max dBA |
|---|---|
| 12,000 / 18,000 Btuh | 46 |
| 24,000 / 30,000 / 36,000 Btuh | 48 |
| 42,000 Btuh | 51 |

2.3 OUTDOOR UNITS – CONSTRUCTION

A. Cabinet
   1. The casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection and have a Munsell 3Y 7.8/1.1 finish.
   2. Mounting feet shall be provided and shall be welded to the base of the cabinet and be of sufficient size to afford reliable equipment mount and stability.
   3. Easy access shall be afforded to all serviceable parts by means of removable panel sections.
   4. The fan grill shall be of ABS plastic.
   5. Cabinet mounting and construction shall be sufficient to withstand 155 MPH wind speed conditions for use in Hurricane condition areas. Mounting, base support, and other installation to meet Hurricane Code Conditions shall be by others.

B. Fan
   1. AC fan motor or DC fan motors are acceptable and will vary based on unit capacity.
   2. The fan blade(s) shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated.
   3. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent external contact with moving parts

C. Coil
   1. The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up and allow maximum airflow. The coil shall be protected with an integral metal guard.
   2. Refrigerant flow from the condenser shall be controlled by means of an electronic linear expansion valve (LEV) metering device. The LEV shall be control by a microprocessor controlled step motor.

D. Refrigerant Lines
   1. All refrigerant lines between outdoor and indoor units shall be of annealed, refrigeration grade copper tubing, ACR Type, meeting ASTM B280 requirements.
   2. Lines shall be individually insulated in twin-tube, flexible, closed-cell, CFC-free (ozone depletion potential of zero), elastomeric material for the insulation of refrigerant pipes and tubes. Insulation to have a thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1” thick insulation shall have a - Flame-Spread Index of less than 25 and a Smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102.

E. Compressor
   1. The compressor for units with a capacity between 12,000 and 36,000 Btuh shall be a DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology.
   2. The compressor for units with a capacity of 42,000 Btuh shall be a Frame Compliant Scroll compressor with Variable Speed Inverter Drive Technology.

3. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which shall result in significant energy savings.
4. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.
5. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.

F. Electrical
1. The electrical power of the unit shall be 208 volts or 230 volts, single phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.
2. Power for the indoor unit shall be supplied from the outdoor unit.
3. The outdoor unit shall be controlled by the microprocessor located in the indoor unit.

## 2.4 INDOOR UNITS – GENERAL

A. The indoor units shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor.

B. The unit, in conjunction with the wired, wall mounted controller shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch.

C. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from the factory.

D. Fans
1. The indoor unit fan shall have multiple high performance, double inlet, forward curve fans driven by a single motor.
2. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
3. The indoor fan shall consist of four (4) speeds: Low, M1, M2, and Hi plus AUTO fan setting. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and sensed space temperature.

E. Filter: Return air shall be filtered by means of an easily removable washable filter. An optional MERV 8 filter shall be furnished

F. Coil
1. The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing.
2. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow.
3. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory.
4. A condensate pan and drain shall be provided under the coil.

5. Condensate Pump: Externally mounted, plenum rated pump.

G. Electrical
1. The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.
2. The power to the indoor unit shall be supplied from the outdoor unit.

H. Control
1. The control system shall consist of a minimum of two (2) microprocessors, one (1) on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable.
2. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit. The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Up to two wired controllers shall be able to be used to control one unit.
3. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.

## 2.5 INDOOR UNIT – WALL MOUNTED

A. The cabinet shall be formed from high strength molded plastic with smooth finish, flat front panel design with access for filter.

B. Cabinet color shall be white. The unit shall be wall mounted by means of a factory supplied, pre-drilled, mounting plate.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Install units level and plumb, maintaining manufacturer's recommended clearances.

B. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC Piping and Equipment."

3.2 CONNECTIONS

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

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

C. Drainage Connections: Comply with applicable requirements in Division 22 Section "Domestic Water Piping." Provide adequate connections for condensate drains.

D. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping." Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. 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.

C. After startup service and performance test change filters.

**END OF SECTION**

**SECTION 238200**

**TERMINAL HEATING EQUIPMENT**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all work required to provide and install the following Terminal Heating Devices indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
   1. Electric Terminal Heat
      a. Unit Heaters
      b. Cabinet Unit Heaters
   2. Gas Fired Terminal Heat
      a. Radiant Tube Heaters

1.2 SUBMITTALS

A. Product Data: Catalog cuts, specifications, installation and maintenance instructions for each type of heater specified.

B. Schedule: List manufacturer, unit type, model number, and performance data for each unit heater.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements: Heaters shall be UL listed.

B. Certification: Affidavit from finned tube radiation manufacturer certifying that element has been tested in accordance with the requirements of IBR Testing and Rating Standard for finned tube radiation.

1.4 MAINTENANCE

A. Special Tools: One (1) tool for each type and size vandal resistant fastener.

## PART 2 - PRODUCTS

### 2.1 CONFIGURATION AND PERFORMANCE

A. Refer to the equipment schedules for additional configuration and performance requirements.

### 2.2 ELECTRIC TERMINAL HEAT

A. Electric Unit Heaters
   1. Acceptable Manufacturers
      a. Berko
      b. Brasch
      c. Indeeco
      d. King Electric
      e. Markel
      f. Modine
      g. Q-Mark
      h. Raywall
      i. Redd-I
      j. Stelpro
      k. Trane
      l. TPI Corp
   2. Unit Casing: Constructed of steel sheet formed, reinforced, and braced for rigidity, with steel louvers or deflectors with sufficient rigidity to prevent vibration at all fan speeds.
      a. Materials:
         1) Galvanized Steel Sheet: ASTM A 653, coating designation G90.
         2) Cold-Rolled Steel Sheet: ASTM A 366, cleaned, degreased and phosphatized.
      b. Factory Finish: Minimum two (2) coat baked enamel finish on exposed surfaces, color as directed.
   3. Provide with discharge nozzle for units to throw air from the specified mounting height to the floor or as specified on the drawings. At a minimum, units shall include the following:
      a. Horizontal Delivery Units: Adjustable horizontal and vertical louvers.
      b. Vertical Delivery Units: Louvered deflector mounted outside fan orifice.
   4. Provide all necessary mounting hardware to support the heater.

B. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550° F at any point during normal operation.

C. Circuit Protection: One (1)-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.

D. Wiring Terminations: Stainless-steel or corrosion-resistant material.
   1. Fan Assembly (Refer to schedule for fan type)
      a. Fan (Propeller): Multiple blade propeller type, statically and dynamically balanced, and directly connected to electric motor.
      b. Fan (Blower): Double width, double inlet (DWDI), forward curved, belt driven,assembly with spider ball bearings.
   2. Motor: Single phase, totally enclosed electric motor of the permanent split capacitor or shaded pole type, with resilient mounting, terminal box for wiring connections, built-in overload protection, and ball or sleeve bearings with oilers, or permanently lubricated bearings.
   3. Refer to schedule for control type and electrical requirements for the unit.

E. Electric Cabinet Unit Heaters
   1. Acceptable Manufacturers
      a. Berko
      b. Brasch
      c. Indeeco
      d. King Electric
      e. Markel
      f. Q-Mark
      g. Raywall
      h. Redd-I
      i. Stelpro
      j. Trane
      k. TPI Corp
   2. Unit Casing: Constructed of steel sheet formed, reinforced and braced for rigidity, with stamped grilles.
      a. Materials:
         1) Galvanized Steel Sheet: ASTM A 653, coating designation G90.
         2) Cold-Rolled Steel Sheet: ASTM A 366, cleaned, degreased and phosphatized.
      b. Factory Finish: Minimum two (2) coat baked enamel finish on exposed surfaces, color as directed.
      c. Insulation: Insulate interior surfaces of casing panels with 1/2 inch glass fiber meeting NFPA 90A requirements.
      d. Vertical Units: Minimum 18 gauge construction with removable front panel.
      e. Horizontal Units: Minimum 18 gauge construction with hinged bottom panel.
   3. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element

ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550° F at any point during normal operation.

a. Circuit Protection: One (1)-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
b. Wiring Terminations: Stainless-steel or corrosion-resistant material.

4. Fan Assembly: Blow thru design.
   a. Fans: Forward curved centrifugal type, double width, statically and dynamically balanced, and directly connected to electric motor.
5. Motors: Three (3) speed, single phase electric motors of the permanent split capacitor or shaded pole type, with resilient mounting, built-in overload protection with automatic reset, and ball or sleeve bearings with accessible oilers, or permanently lubricated bearings.
6. Filter Section: Built-in filter frame mounted at air inlet with disposable air filters.
   a. Vertical Units: Filters removable without removing front panel for cabinet type units.
   b. Horizontal Units: Filters removed by pivoting hinged bottom panel.

F. Refer to schedule for cabinet style, control type and electrical requirements for the unit.

G. Refer to schedule for element type, duct installation type and control type for the unit.

## 2.3 GAS FIRED RADIANT TUBE HEATERS

1. Acceptable Manufacturers
   a. Detroit Radiant
   b. Roberts Gordan
   c. Schwank
2. Low intensity infrared heating system consisting of burner, controls, heating elements, and heat reflectors. Burner shall be sealed combustion type designed for ducted combustion air and exhaust.
3. Casing: The controls, combustion air blower and burner shall be housed in a water-resistant casing, providing weatherproof protection. The burner and control box casing shall be constructed of minimum 20 gauge aluminized steel with a baked enamel finish.
4. Heat Exchanger: The heat exchanger tubes and combustion chamber shall be constructed of minimum 16 gauge, 4" O. D. aluminized steel. The first combustion tube for gas inputs 150,000 Btuh and greater shall be 16 gauge 4" O.D. titanium aluminized steel. The heat exchanger tubes must be used in conjunction with reflectors. The reflector can be adjusted from 0° to 45° from the horizontal plane. Reflectors shall be of bright polished aluminum.
5. Controls: Input power to the infrared heater(s) shall be 115V/60Hz/1ph. Heater(s) shall be equipped with a direct four (4) trial (three (3) retrial), 100% shut-off hot surface ignition control system with a separate flame sensor. Infrared heater(s) shall be equipped with a 115V/25V control transformer. Provide with low voltage thermostat. Thermostat shall operate on 25V. Heater(s) will be equipped with a pre-purge mode, a differential pressure switch, and an indicator light to prove proper operation of the combustion air blower. All controls shall be rated for a maximum inlet pressure of 1/2 PSI gas pressure.
6. Motor: Each heater shall have a single motor. The combustion air blower motor shall be totally enclosed in the control box and the motor shall be protected by a thermal overload switch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the Work of this section in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

B. Gas Fired Radiant Tube Heaters
   1. Install units per manufacturer's instructions. Maintain required clearance to combustibles.

**END OF SECTION**

**SECTION 238416**

**DEHUMIDIFICATION UNIT**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following equipment indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment Included in This Section
   1. Dehumidification Unit.

1.2 SUBMITTALS

A. Submit shop drawings per Section 1.

B. Submit operation and maintenance data. Include instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists.

1.3 EXTRA STOCK

A. Install clean 2" 30% ASHRAE efficiency filters in units at time of final completion.

B. Provide one additional set of replacement filters for all units.

PART 2 - PRODUCTS

2.1 DEHUMIDIFICATION UNIT

A. Housing
   1. Steel powdercoated cabinet
   2. Removable access panels
   3. Provide insulated, corrosion resistant drain pan under coil and fan sections.

B. Fans
   1. Centrifugal, statically and dynamically balanced.
   2. Provide with belt guards

C. Condensate Pump
   1. Externally mounted, plenum rated pump.

**END OF SECTION**

**SECTION 260500**

**COMMON WORK RESULTS**

PART 1 - GENERAL

1.1 SCOPE

A. The work under this section includes basic electrical requirements, which are applicable to all Division 26, 27 and 28 sections.

B. Overview of Work
   1. Power Distribution
   2. Branch Power
   3. Equipment Connections
   4. Lighting and Lighting Controls
   5. Low Voltage Systems (such as: fire alarm, nurse call, etc.)
   6. Lightning Protection
   7. Commissioning

C. In these documents, "Contractor" refers to the Electrical Contractor and all their subcontractors, unless listed otherwise. The division of Work with the electrical scope is the responsibility of the General Contractor/Construction Manager.

D. The Contractor is responsible for providing and installing fully functional systems.

E. If the Work is shown on the drawings or noted in the specifications, it shall be included by the Contractor.

F. If equipment is provided by the Contractor, it shall be installed by the Contractor, unless noted otherwise.

G. Drawings are necessarily diagrammatic by their nature and are not intended to show every connection in detail or every conduit in its exact location. Carefully investigate structural and finish conditions and coordinate the separate trades in order to avoid interference between the various phases of Work. Organize and lay out Work so that it will be concealed in furred chases and suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. Install all Work parallel or perpendicular to building lines unless otherwise noted.

H. The intent of the Drawings is to establish the types of systems and functions; not to set forth each item essential to the functioning of the system. Install the Work complete, including minor details necessary to perform the function indicated. Review pertinent Drawings and adjust the Work to conditions shown. Where discrepancies occur between Drawings, Specifications, and actual field conditions, immediately notify the Architect and Engineer for interpretations.

I. All sizes as given are minimum except as noted.

J. All materials shall be new (unless noted or stated otherwise) and free of defect.

K. All work shall be subject to the Architect's, Engineer's, and Owner's observations from the commencement of work until the acceptance of the completed work.

L. Owner Furnished Equipment
   1. The following items are provided by the Owner and installed by the contractor:
      a. Existing Kohler 230kW generator with integral belly fuel tank.
   2. Conduit pathways for power and systems distribution between buildings are existing (installed in Bid Package #1). Under this Contract, the Contractor shall provide all remaining work required for a complete and operational installation, including, but not limited to, final conduit extensions, routing modifications as required, conductors, terminations, testing, and equipment connections.

## 1.2 RELATED WORK

A. Applicable provisions of Division 0 and Division 1 govern work under this Section.

## 1.3 REFERENCES

A. All work shall conform to the most current version of all applicable codes and standards or the version adopted by the jurisdiction.

B. Codes
   1. Florida Building Code, 2023
   2. Florida Building Code – Accessibility, 2023
   3. ADA Standards for Accessible Design, 2010
   4. Florida Building Code – Energy Conservation, 2023
   5. NFPA – National Fire Protection Association
      a. NFPA 70 (National Electric Code)
      b. NFPA 72 (National Fire Alarm and Signaling Code)
      c. NFPA 101 (Life Safety Code)
   6. State or City Codes for the Escambia County and the City of Pensacola.

C. Standards
   1. ANSI
   2. Escambia County Published Standards

D. Governing Bodies
   1. Owner's Insurance Company
   2. State Fire Marshall
   3. AHJ – Authority Having Jurisdiction
   4. UL - Underwriters Laboratories

## 1.4 SUBMITTALS

A. The review of Shop Drawings by the Engineer is for general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. Corrections or comments made on the shop drawings during this review do not relieve the contractor from compliance with the requirements of the Plans and Specifications. Approval of a specific item shall not include approval of an assembly of which the item is a component. The Contractor is responsible for: dimensions to be confirmed and correlated at the jobsite; information that pertains solely to the fabrication processes or to the means, methods, techniques, sequences and procedures of construction; coordination with the Work of all trades; and for performing all work in a safe and satisfactory manner.

B. Refer to individual technical Specification sections for specific submittal requirements.

C. Submission of Shop Drawings electronically in .PDF format is required.

D. If hard copies of shop drawings are required for this project, coordinate the quantity with the Architect and General Contractor. Provide one (1) copy for the Engineer's records.

E. The Engineer will review one (1) resubmittal for each product. If additional resubmittals are required, the Contractor shall be responsible to bear the cost for the Engineer to recheck and handle the additional shop drawing submittals. Documents will not be reviewed until payment is agreed upon.

F. Contractor may request electronic files from the Engineer if needed to complete their Shop Drawings. An Electronic File Request Form will be sent to the contractor if files are requested and must be completed and signed before the AutoCAD files are released to the Contractor.

G. All submittals for equipment and materials shall be reviewed and approved by the Engineer prior to the fabrication or release by the contractor. This includes the coordination of equipment between trades. The release, purchase, installation or fabrication of any items prior to the contractor receiving an approved shop drawing will be at the contractor's own risk. Any rework that results will be provided by the contractor at no cost to the Owner or design team.

H. Submittals must be reviewed and approved by the Contractor before submitting to the Engineer.

I. 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.

## 1.5 ELECTRONIC DOCUMENT RELEASE

A. Electronic versions of the bid documents will be made available to the contractors for use during the bidding process and to help generate fabrication drawings for various systems. A summary of the requirements for the various document types is listed below:
   1. PDF
      a. Contact the Construction Manager or Architect to obtain a PDF version of the Bid Documents. No Document Release Form is required.

2. AutoCAD
    a. KEDbluestone Engineering can provide an AutoCAD version of the bid documents for the contractor to use for generating shop drawings and fabrication drawings. This will include plan drawings with the architectural background. The contractor is responsible for incorporating any modifications that occur during bidding by all disciplines. Details and schedules will not be included.
    b. A document release form (see attached) will be required to be completed by the contractor to determine the version of AutoCad and drawings required. No fee is associated with these drawings.
3. REVIT
    a. The REVIT drawings will be converted to AutoCAD and then transferred to the contractor.
    b. KEDbluestone Engineering can provide an AutoCAD version of the bid documents for the contractor to use for generating shop drawings and fabrication drawings. This will include plan drawings with the architectural background. The contractor is responsible for incorporating any modifications that occur during bidding by all disciplines. Details and schedules will not be included.
    c. A document release form (see attached) will be required to be completed by the contractor to determine the version of AutoCad and drawings required.
    d. Submittal of the document release form fee will be required prior to the AutoCAD files being transmitted.

## 1.6 SUBSTITUTIONS

A. All manufacturers listed as Acceptable Manufacturers in each specification section are considered equal to the basis of design. The basis of design is preferred and will take precedence. Any products from an alternate approved manufacturer need to meet the requirements and performance specified and shall be equal to the basis of design.

B. The Contractor may request permission for a substitution of any item (equipment or material), subject to the following conditions:
    1. Submit substitution requests in writing to the Engineer, on a form supplied by the Engineer. A sample copy of this form is included at the end of this section. An electronic copy can also be provided to the Contractor by the Engineer.
    2. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contractor documents, the Contractor is responsible for all costs involved in integrating the equipment or accessories into the system and the assigned space and for obtaining the performance from the system into which these items are placed as well as any re-design costs incurred by the Architect or Engineer. The Contractor is also responsible for coordinating changes required by other trades.
    3. Any requests for alternate manufacturers must be submitted to the Architect/Engineer at least ten (10) days prior to bid day. Incomplete substitution requests will not be considered.

C. Approval
    1. No work involving requests for substitution shall commence without written approval on the provided form by the Engineer.

2. Any work started or material ordered/installed by the Contractor without written approval shall be removed/repaired at the sole expense of the contractor. The Contractor will also be responsible for any costs incurred by the Owner for such rework.

## 1.7 COORDINATION DRAWINGS

A. The Electrical Contractor shall be responsible for providing electrical equipment layout information to the Division 23 Mechanical Contractor for use in creating coordination drawings. The drawings will need to incorporate piping, ductwork, equipment, lighting, conduits, building structure and all other building and system components that will need to be coordinated for proper systems installation and operation. The Division 23 Mechanical Contractor will be responsible for producing the coordination drawings.

B. The drawings will be 1/4" scale.

C. Coordination meetings will be conducted on site with all concerned contractors present. Representatives from the Owner, Architect or Engineer will also be present to review conflicts and approve contractor variations to the contract documents.

## 1.8 QUALITY ASSURANCE

A. Warranty
   1. Equipment warranty shall be a minimum of one (1) year from date of factory supervised startup or from the date of substantial completion, whichever is later.
   2. Contractor shall warranty all of their work for one (1) year from the date of substantial completion

B. These documents are diagrammatical in nature and intended to convey scope and general arrangement of the electrical and technology systems. Not all conduits, junction boxes, accessories, etc. are shown on Plan. If items are required to make a system fully operational but not shown on Plan or in these Specifications, they shall be included by the Contractor.

C. The intent of the Drawings is to establish the types of systems and functions; not to set forth each item essential to the functioning of the system. Install the Work complete, including minor details necessary to perform the function indicated. Review pertinent Drawings and adjust the Work to conditions shown. Where discrepancies occur between Drawings, Specifications, and actual field conditions, immediately notify the Architect and Engineer for interpretations.

D. It is the contractor’s responsibility to determine all utility routing prior to purchase and installation of material.

E. The Contractor shall report any discrepancies between these documents and site conditions immediately to the Engineer prior to submitting a bid or starting work. Submittal of a bid indicates that the contractor and the contractor’s subcontractors have carefully and thoroughly reviewed the Drawings, Specifications, and other construction documents and have found them complete and free from ambiguities and sufficient for the purposes intended.

F. Install all equipment per the manufacturer's requirements / recommendations.

G. No equipment provided or installed shall contain mercury.

H. Manufacturer / Supplier Inspection & Startup
   1. The following equipment shall have a factory representative perform start-up. The procedure shall be documented and submitted to the design team and Owner. Include copies of startup reports in the Operations & Maintenance Manuals.
      a. Lighting Control Systems, including occupancy sensor controls
      b. Generators
      c. Transfer Switches

I. All equipment shall be UL listed where applicable.

## 1.9 REGULATORY AND UTILITY REQUIREMENTS

A. Contractor is responsible for coordinating all required site inspections by authorities having jurisdiction. Contractor shall notify General Contractor/Construction Manager of all scheduled inspections seven (7) working days prior to site visit.

B. Contractor is responsible for paying for all fees, permits, and inspections that are required to complete their work.

C. Contractor shall include all work required to install new utilities and meters as shown on drawings.

## 1.10 PROTECTION OF FINISHED SURFACES

A. Furnish one (1) can of touch-up paint for each different color factory finish for equipment furnished by the Contractor. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

## 1.11 SEALING AND FIRESTOPPING

A. Sealing and firestopping of sleeves/openings between conduits, cable trays, wireways, troughs, 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.

## 1.12 WORK BY OWNER AND/OR OWNER AGENCY

A. Electrical testing not described in these contract documents will be by the Owner under separate contract(s).

1.13 OMISSIONS

A. No later than ten (10) days before bid opening, the Contractor shall call the attention of the Architect and Engineer to any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

1.14 DELIVERY, STORAGE, AND HANDLING

A. All equipment and materials shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.

B. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Equipment shall include but not be limited to switchboards, panelboards, transformers, , motor controllers, enclosures, controllers, circuit protective devices, cables, wire, light fixtures, electronic equipment, and accessories.

C. During installation, equipment shall be protected against entry of foreign matter; and be vacuum-cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.

D. Take such precautions as are necessary to protect apparatus and materials from damage. Damaged equipment shall be, as determined by the Owner and/or Engineer, placed in first class operating condition or be returned to the source of supply for repair or replacement.

E. Protect factory finish from damage during construction operations until acceptance of the Project. Restore any finishes that become stained or damaged to Owner’s satisfaction.

1.15 WORK SEQUENCE AND SCHEDULING

A. During the construction period coordinate electrical schedule and operations with the General Contractor/ Construction Manager.

1.16 DIVISION OF WORK AND COORDINATION

A. The Electrical Contractor is responsible for providing and installing power wiring up to equipment provided by others for a single point connection. Internal wiring of equipment provided by others shall be the responsibility of the manufacturer or the contractor responsible for providing and installing the equipment.

B. Controls, disconnect switches, starters, variable frequency drives, etc. shall be provided and installed by the contractor noted on the plans and in the specifications. It is the responsibility of the Contractor to request written clarification for any ambiguity regarding division of work and coordination at least ten (10) days prior to bid.

C. See Section 230900 for scope of wiring required for Temperature Control systems.

D. Utilities routed within the building shall be installed in an orderly manner. All work will be coordinated with other disciplines prior to installation. The following list ranks the priority of the utilities to be installed:
   1. Light fixtures
   2. Gravity piping
   3. Ductwork
   4. Cable tray
   5. All other piping
   6. Electrical conduits

E. 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.

F. Coordinate work with the Testing and Balancing (TAB) Contractor. Verify system completion to the TAB Contractor such as fire/smoke damper integration ready for testing, power provided to control panels and control devices as specified, and power provided to all equipment and dampers that are required to operate for testing and balancing. Assist the TAB Contractor as needed to complete their work.

G. Arrange for conduit and raceway spaces, chases, slots, and openings in building structure during progress of construction, to allow for electrical installations.

H. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

I. Coordinate requirements for access panels and doors for electrical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

## 1.17 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

B. In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation as applicable:
   1. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
   2. A control sequence describing start-up, operation, and shutdown.
   3. Description of the function of each principal item of equipment.
   4. Installation instructions.
   5. Safety precautions for operation and maintenance.
   6. Diagrams and illustrations.
   7. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers and replacement frequencies.
   8. Performance data.
   9. Where applicable, pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of

supply, recommended spare parts, and name of servicing organization.

10. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.

## 1.18 RECORD DRAWINGS

A. The Contractor shall maintain at least one (1) copy of the Specifications and Drawings on the job site at all times.

B. The Architect will provide the Contractor with a suitable set of Contract Drawings on which daily records of changes and deviations from contract shall be recorded. Dimensions and elevations on the record drawings shall locate all buried or concealed piping, conduit, or similar items.

C. The daily record of changes shall be the responsibility of Contractor's field superintendent. No arbitrary mark-ups will be permitted.

D. At completion of the project, the Contractor shall submit the marked-up record drawings to the General Contractor/Construction Manager prior to final payment.

# PART 2 - PRODUCTS

## 2.1 GENERAL

A. Conditions: Provide new products of manufacturers regularly engaged in production of such equipment. Provide the manufacturer's latest standard design for the type of product specified.

B. Space Limitations: Equipment selected shall conform to the building features and shall be coordinated with all components. Do not provide equipment that will not meet arrangement and space limitations. Contractor shall submit room layouts with submitted items shown drawn to scale. Submittals will be rejected without floor plan Drawings showing submitted items.

C. Common Source: Equipment specified in Sections 262200 Low Voltage Transformers, 262416 Panelboards, 262728 Disconnect Switches, 262730 Contactors, 262816 Enclosed Switches and Circuit Breakers shall be provided by the same manufacturer.

## 2.2 ACCESS PANELS AND DOORS

A. Provide access panels and/or doors where required to maintain access to the electrical installation and where noted on the Drawings.

B. Lay-in Ceilings
   1. Removable lay-in ceiling tiles in 2 x 2 foot or 2 x 4 foot configuration provided under other divisions are sufficient; no additional access provisions are required unless specifically indicated.

C. Plaster/Gypsum Walls and Ceilings
   1. 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".

## 2.3 IDENTIFICATION

A. See Electrical Section 260553 – Identification.

## 2.4 SEALING AND FIRESTOPPING

A. Fire and/or Smoke Rated Penetrations
   1. Manufacturers
      a. 3M, STI/SpecSeal, Tremco, Hilti or approved equal.
   2. All firestopping systems shall be by the same manufacturer.
   3. 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 judgement can be based upon.
   4. Product
      a. Firestop systems shall be UL listed or tested by an independent testing laboratory approved by the Department of Commerce.
      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.

B. 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

3.1 EXCAVATION AND BACKFILL

A. Perform all excavation and backfill work to accomplish indicated electrical systems installation in accordance with Division 31.

3.2 CONCRETE WORK

A. The Division 3 Contractor will perform all cast-in-place concrete unless noted otherwise elsewhere. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for the support of electrical equipment.

3.3 CUTTING AND PATCHING

A. Refer to Division 1, General Requirements, Cutting and Patching.

3.4 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.

3.5 EQUIPMENT ACCESS

A. Install all conduit, raceways, 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/Construction Manager, 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/Construction Manager and reimburse the General Contractor/Construction Manager for installation of those access doors.

3.6 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 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 semi-recessed heating units installed in/on architectural surfaces.

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. Cooperate with the testing consultant in ensuring specification Section 26 05 04 compliance. Verify system completion to the testing consultant. Demonstrate the starting, interlocking and control features of each system so the testing contractor can perform its work.

E. Coordinate clearances in front of and above electrical distribution equipment with other trades to avoid interference issues. Maintain clearances as defined in the National Electrical Code. Pipes, ducts, etc. shall not be installed above electrical distribution equipment.

F. Coordinate exact locations of floor boxes and furniture wall feeds with the furniture vendor.

## 3.7 SLEEVES

A. Pipe sleeves for conduits 6" in diameter and smaller, in new poured concrete construction, shall be schedule 40 steel pipe, plastic removable sleeve or sheet metal sleeve, all cast in place.

B. In wet area floor penetrations, top of sleeve to be 2 inches above the adjacent floor. In existing wet area floor penetrations, core drill sleeve openings large enough to insert schedule 40 sleeve and grout the area around the sleeve. If a pipe clamp resting on the sleeve supports the pipe penetrating the sleeve, weld a collar or struts to the sleeve that will transfer weight to the existing floor structure. Wet areas for this paragraph are rooms or spaces containing air handling unit coils, converters, pumps, chillers, boilers, and similar waterside equipment.

C. Pipe penetrations in existing concrete floors that are not in wet areas may omit the use of schedule 40 sleeve and use the core drilled opening as the sleeve.

## 3.8 SEALING AND FIRESTOPPING

A. Fire and/or Smoke Penetrations
   1. Install approved product in accordance with the manufacturer's instructions where a raceway (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.

B. 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.
   2. 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, telephone/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.

## 3.9 HOUSEKEEPING AND CLEAN UP

A. The Contractor shall clean up and remove from the premises, daily, 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.

## 3.10 TESTING

A. Test Conditions
   1. Place circuits and equipment into service under normal conditions, collectively and separately, as may be necessary to determine satisfactory operation. Perform specified tests in the presence of the Owner's representative(s). Furnish all instruments, wiring, equipment and personnel required for conducting tests. Demonstrate that the equipment operates in accordance with requirements of the Contract Documents. Special tests on certain items are specified hereinafter.
   2. Where specified that the testing be performed by an independent testing company, an Owner-approved National Electrical Testing Association (NETA) certified testing company shall be used. Submit copies of test reports.
   3. Prior to testing, Contractor shall submit to Owner for approval, installation verification Prefunctional Checklists and Functional Performance Test procedures. These shall be used for documentation as part of the commissioning process.
   4. All instruments required for conducting the tests shall be NIST (National Institute for Standard and Technology) certified or traceable, and calibrated at the time of testing.

B. Test Dates: Schedule final acceptance sufficiently in advance of the Contract date to permit completion of any necessary adjustment or alterations within the number of days allotted for completion of the Contract. Provide written notification to Owner at least fourteen (14) calendar days in advance of Functional Performance Test dates.

C. Retests: If retesting is required due to initial failure, conduct retests of such time duration as may be necessary to assure proper functioning of adjusted or altered parts or items of equipment. Any resultant delay as a result of such necessary retests does not relieve the Contractor of Contractor's responsibility under this Contract.

D. Circuit Verification: All 120-volt single-phase circuits shall be verified to match the Drawings and panel schedules by "ringing out" each circuit in the presence of the Owner's representative(s).

E. Refer to Commissioning Specification Sections for additional start-up, prefunctional and operational checkout, and for functional performance test procedures.

## 3.11 OWNER TRAINING

A. Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 2 hours or for the duration noted in the technical Specifications.

## 3.12 NFPA 70E COMPLIANCE

A. The Electrical Contractor will be responsible for providing ARC Flash labeling for all electrical distribution equipment installed or modified as part of this contract. This includes but is not limited to: Identification of ARC Flash Boundaries, Application of Proper labels, and Identification of Proper Labels, and Identification of Proper Personal Protective Equipment.

B. The Contractor must ensure that personnel working on the equipment while energized are qualified to do so and are wearing the appropriate ARC Flash personal protective equipment. Documentation of this training is required.

E. The Electrical Contractor will include in his bid the cost to hire a qualified Engineer to perform the necessary ARC Flash study.

## 3.13 PROJECT CLOSEOUT REQUIREMENTS

A. Final project closeout tasks
   1. Deliver all spare parts listed in each specification section. Deliver to Owner chosen location.
   2. All equipment labeled per specifications.
   3. All equipment cleaned and ready for use. Install new fuses in all equipment with fuses; do not use Owner's spare fuses.

B. Contractor requirements
   1. Marked up drawings and specifications provided to Engineer for incorporation of as-built drawings or to serve as the as-built drawings depending on the project requirements. As-built drawings shall be clean and legible.
   2. Operation and Maintenance (O & M) Manuals shall include the following:

a. Contractor contact for warranty work
b. Approved shop drawings, incorporating all review comments
c. Warranty copies
d. Equipment start-up reports
e. Operation and maintenance instructions

3. Utility Rebate Forms
   a. Contractor shall submit completed energy rebate forms for each piece of equipment that is eligible for a rebate. Eligible equipment shall include, but not be limited to the following:
      1) Interior Lighting
      2) Exterior Lighting
      3) Occupancy Sensors
   b. Contractor to complete information regarding equipment. Submit form to Owner; Owner will complete Owner's contact information and send the completed form to the utility.

C. Three (3) final approved O & M Manuals shall be delivered to Owner. Each manual shall be an appropriately sized three (3) ring binder with a vinyl cover and printed spine and cover labels. Each section shall have a printed divider tab. Each section shall be listed in a table of contents at the beginning of the manual.

**END OF SECTION**

(ELECTRONIC DOCUMENT RELEASE FORM & SUBSTITUTION REQUEST FORMS ATTACHED)

**Document Release Form**

**Information Requested:**

| |
|---|
| Project Name: |
| Drawings Requested: |
| |
| |

**Media Type:** (Check all that are applicable)

- ☐ AutoCAD DWG Files (Version _____)
- ☐ REVIT Files (Version _____)
- ☐ Adobe PDF Files
- ☐ Other

**Requesting Party:**

Name:

Company:

Signature:

Date:

Address 1:

Address 2:

Email Address:

Phone #:

**KEDbluestone Use:**

Form Sent By:

Date:

KEDbluestone Project #:

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**SUBSTITUTION REQUEST FORM (DURING BIDDING)**

We submit for your consideration the following product instead of the specified item for the following project:

PROJECT: _____

| SPEC. SECTION | SPEC. TITLE | PARAGRAPH | SPECIFIED ITEM |
|---|---|---|---|
| _____ | _____ | _____ | _____ |

Proposed Substitution: _____

| MANUFACTURER | TRADE NAME | MODEL NO. |
|---|---|---|
| _____ | _____ | _____ |

Attached data includes product description, specifications, drawings, photographs, and performance and test data adequate for evaluation of the request; applicable portions of the data are clearly identified.

Attached data also includes a description of changes to the Contract Documents that the proposed substitution will require for its proper installation.

---

The Undersigned certifies:

- Proposed substitution has been fully investigated and determined to be equal or superior in all respects to specified product.
- Same warranty will be furnished for proposed substitution as for specified product.
- Same maintenance service and source of replacement parts, as applicable, is available.
- Proposed substitution will have no adverse effect on other trades and will not affect or delay progress schedule.
- Proposed substitution does not affect dimensions and functional clearances.
- Payment will be made for changes to building design, including Architectural and Engineering design, detailing, and construction costs caused by the substitution.

Submitted by:

_____
Signature

_____
Firm

_____
Telephone Email Date

Engineer's Review and Action

☐ Substitution Approved
☐ Substitution Approved As Noted
☐ Substitution Rejected
☐ Substitution Request Received Too Late

Signed by:

_____
Date

Supporting Data Attached:

☐ Drawings ☐ Product Data ☐ Samples ☐ Tests ☐ Reports ☐ Other _____

**SUBSTITUTION REQUEST FORM (AFTER BIDDING)**

We submit for your consideration the following product instead of the specified item for the following project:

PROJECT: _____

| SPEC. SECTION | SPEC. TITLE | PARAGRAPH | SPECIFIED ITEM |
|---|---|---|---|
| _____ | _____ | _____ | _____ |

Proposed Substitution: _____

| MANUFACTURER | TRADE NAME | MODEL NO. |
|---|---|---|
| _____ | _____ | _____ |

| INSTALLER | PHONE NO. |
|---|---|
| _____ | _____ |

History: ☐ New Product ☐ 2-5 years old ☐ 5-10 years old ☐ More than 10 years old

Differences between proposed substitution and specified product: _____

Proposed substitution affects other parts of Work: ☐ No ☐ Yes; explain _____

Proposed substitution changes Contract Time: ☐ No ☐ Yes [Add] [Deduct] _____ days

Savings to Owner for accepting substitution: $_____

---

The Undersigned certifies:

- Proposed substitution has been fully investigated and determined to be equal or superior in all respects to specified product.
- Same warranty will be furnished for proposed substitution as for specified product.
- Same maintenance service and source of replacement parts, as applicable, is available.
- Proposed substitution will have no adverse effect on other trades and will not affect or delay progress schedule.
- Cost data as stated above is complete. Claims for additional costs related to accepted substitution which may subsequently become apparent are to be waived.

- Proposed substitution does not affect dimensions and functional clearances.
- Payment will be made for changes to building design, including Architectural and Engineering design, detailing, and construction costs caused by the substitution.
- Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

Submitted by:

_____
Signature

_____
Firm

_____
Telephone Email Date

Engineer's Review and Action

☐ Substitution Approved
☐ Substitution Approved As Noted
☐ Substitution Rejected
☐ Substitution Request Received Too Late

Signed by:

_____
Date

Supporting Data Attached:

☐ Drawings ☐ Product Data ☐ Samples ☐ Tests ☐ Reports ☐ Other _____

**SECTION 260504**

**CLEANING AND TESTING**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide the required cleaning, repair, adjustment, calibration, maintenance and testing of electrical equipment, as specified herein. This applies only to new electrical and existing electrical equipment being furnished, modified, worked on or serviced by this contractor for this project.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

PART 2 - PRODUCTS – (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL INSPECTION AND CLEANING OF ALL ELECTRICAL EQUIPMENT

A. Inspect for physical damage and abnormal mechanical and electrical conditions.

B. Any item found to be out of tolerance, or in any other way defective as a result of the required testing, shall be reported to the Engineer. Procedure for repair and/or replacement will be outlined. After appropriate corrective action is completed the item shall be re-tested.

C. Compare equipment nameplate information with the latest single line diagram and report any discrepancies.

D. Verify proper auxiliary device operation and indicators.

E. Check tightness of accessible bolted electrical joints. Use torque wrench method.

F. Make a close examination of equipment and remove any shipping brackets, insulation, packing, etc. that may not have been removed during original installation.

G. Make a close examination of equipment and remove any dirt or other forms of debris that may have collected in existing equipment or in new equipment during installation.

H. Clean All Equipment:

1. Vacuum inside of panelboards, switchboards, generator, transformer core and coils, transfer switches, generator docking station, fire alarm panels, comm/data, security panel, etc.
2. Loosen attached particles and vacuum them away.
3. Wipe all insulators with a clean, dry, lint free rag.
4. Clean insulator grooves.
5. Inspect equipment anchorage.
6. Inspect equipment and bus alignment.
7. Check all heater elements for operation and control.
8. Lubricate nonelectrical equipment per manufacturer's recommendations.

I. Electrical Tests -- Below 600 Volts:
1. All secondary cables from the utility transformer(s) to the secondary switchboard(s) shall be subjected to insulation tests using a 500 vdc megger.
2. Visually inspect cables, lugs, connectors and all other components for physical damage and proper connections
3. Check all cable connectors for tightness (with a torque wrench) and clearances. Torque test conductor and bus terminations to manufacturer's recommendations.
4. Check for proper grounding resistance at all services and at transformers. Resistance shall be 5 ohms maximum.

J. Above 600 volts:
1. Above 600 volt testing will be performed under a separate contract.

## 3.2 PANELBOARDS

A. Torque all the connections per the manufacturers spec. Verify phase wires, color coding, separate neutral and mechanical bonding. Verify circuit breaker operation. Verify the directory is typed and reflects as-built conditions.

## 3.3 LIGHT FIXTURES

A. Check the bonding and proper lumen output and orientation where applicable. Verify that recessed fixtures are installed with hold down clips where required. Confirm operation of the fixture with the proper switch or sensor.

## 3.4 OCCUPANCY SENSORS

A. Confirm operation of the sensor per the manufacturers spec.

## 3.5 BATTERY PACK EMERGENCY LIGHTING

A. Verify the operation per the manufacturers spec and run all of the diagnostic steps. Confirm proper grounding and location.

3.6 GENERATORS

A. Refer to Section 263200.

3.7 AUTOMATIC TRANSFER SWITCHES

A. Coordinate with the generator and the subsequent tests.

**END OF SECTION**

**SECTION 260519**

**LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required for furnishing and installing required wiring and cabling systems including pulling, terminating and splicing.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section

B. Section 260533 Raceway and Boxes

C. Section 260553 Identification

D. Section 260800 Commissioning of Electrical Systems

1.3 SUBMITTALS

A. Submit product data: Provide for each cable assembly type.

B. Submit factory test reports: Indicate procedures and values obtained.

C. Submit shop drawings for modular wiring system including layout of distribution devices, branch circuit conduit and cables, circuiting arrangement, and outlet devices.

D. Submit manufacturer's installation instructions. Indicate application conditions and limitation of use stipulated by product testing agency specified under Regulatory Requirements.

1.4 PROJECT CONDITIONS

A. Verify that field measurements are as shown on Drawings.

B. Conductor sizes are based on copper.

C. All conductors shall be copper.

D. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet project conditions.

E. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

## PART 2 - PRODUCTS

### 2.1 GENERAL

A. All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of manufacturer's stock.

B. All conductors shall be copper.

C. Insulation shall have a 600 volt rating.

D. All conductors shall be stranded

E. Stranded conductors may only be terminated with UL OR ETL Listed type terminations or methods: e.g. stranded conductors may not be wrapped around a terminal screw but must be terminated with a crimp type device or must be terminated in an approved back wired method.

### 2.2 BUILDING WIRE

A. Acceptable Manufacturers: American Insulated Wire Corp., BICC General Cable Industries Inc., Cerro Wire & Cable Co. Inc., Pirelli Cable Corp., Rome Cable Corp., or Southwire Co.

B. Single Conductor Insulated Wire.
   1. FEP, THHN, THW, THW-2, THWN, THWN-2, XHH, XHHW, or XHHW-2: Wiring in dry or damp locations (except where special type insulation is required).
   2. THWN, THWN-2, XHHW, XHHW-2: Wiring in wet locations (except where type USE or USE-2 insulated conductors are specifically required, or special type insulation is required).
   3. THHN, THWN or THWN-2: Wiring installed in existing raceway systems (except where special type insulation is required).
   4. THHN, THW-2, THWN-2, XHHW, or XHHW-2: Wiring for lighting circuits except where fixture listing requires wiring rated higher than 90° C.
   5. THWN Marked “Gasoline and Oil Resistant”: Wiring to gasoline and fuel oil pumps.
   6. USE or USE-2: Wiring indicated on the drawings to be direct burial in earth.
   7. USE or USE-2 Marked “Sunlight Resistant”:
      a. Service entrance wiring from overhead service to the service equipment.
      b. Wiring exposed to the weather and unprotected (except where special type insulation is required).

### 2.3 WIRING CONNECTORS

A. Split Bolt Connectors: Not acceptable unless noted otherwise.

B. Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment pads or terminals. Not approved for splicing.

C. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller.

D. All wire connectors used in underground or exterior pull boxes shall be gel filled twist connectors or a connector designed for damp and wet locations.

E. Mechanical Connectors:
   1. Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.

F. Insulated Connector Blocks:
   1. Conductor count, size, and entry configuration to match application.
   2. UV rated.
   3. Dual rated for use with copper or aluminum conductors.
   4. 600 volt, 90° C termination rating.
   5. Caps for sealing wrench access port.

G. Compression (crimp) Connectors:
   1. Long barrel; seamless, tin-plated electrolytic copper tubing; internally beveled barrel ends. Connector shall be clearly marked with the wire size and type and proper number and location of crimps.

## 2.4 TAGS

A. Precision engrave letters and numbers with uniform margins, character size minimum 3/16 inches high.
   1. Phenolic: Two (2) color laminated engraver's stock, 1/16 inch minimum thickness, machine engraved to expose inner core color (white).
   2. Aluminum: Standard aluminum alloy plate stock, minimum .032 inches thick, engraved areas enamel filled or background enameled with natural aluminum engraved characters.

## 2.5 WIRE MANAGEMENT

A. Cable Clamps and Clips, Cable Ties, Spiral Wraps, etc: Catamount/T&B Corp., or Ideal Industries Inc.

# PART 3 - EXECUTION

## 3.1 GENERAL WIRING METHODS

A. Install electrical cable, wire and connectors as indicated, in accordance with the manufacturer's written instructions, the applicable requirements of NEC, and as required to ensure that products serve the intended functions.

B. Cables shall be selected on the basis of their purpose and UL listing.
   1. Generally, use Types THWN, XHHW and THNN in building interiors and other dry locations.
   2. Outdoors and in underground raceways, use Type THWN or other conductor type rated for wet location as required by NEC 300.5(B).
   3. Conductors subject to abrasion, such as in lighting poles, shall be Type THWN or THHN.

C. All wire and cable shall be installed in conduit.

D. Do not use wire smaller than 12 AWG for power and lighting circuits. Minimum size for control circuits shall be 14 AWG copper stranded.

E. All conductors shall be sized to prevent excessive voltage drop at rated circuit ampacity.

F. Conductors shall be sized to limit voltage drop to a maximum of 3 percent on branch circuits and 5 percent total for feeder and branch circuit combinations at the design load. As a minimum, utilize No. 10 AWG copper conductors for 20-ampere, 120-volt branch-circuit homeruns exceeding 100 feet and for 20-ampere, 277-volt branch-circuit homeruns exceeding 200 feet. Increase conductor size as required to maintain the specified voltage drop criteria

G. Make conductor lengths for parallel conductors equal.

H. Splice only in junction or outlet boxes.

I. No conductor less than 10 AWG shall be installed in exterior underground conduit.

J. Neatly train and lace wiring inside boxes, equipment, and panelboards.

## 3.2 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use Listed wire pulling lubricant for pulling 4 AWG and larger wires and for other conditions when necessary.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

C. Completely and thoroughly swab raceway system before installing conductors.

D. Place all conductors of a given circuit (this includes phase wires, neutral (if any), and ground conductor) in the same raceway. If parallel phase and/or neutral wires are used, then place an equal number of phase and neutral conductors in same raceway or cable.

## 3.3 WIRING CONNECTIONS AND TERMINATIONS

A. Splice only in accessible junction boxes.

B. Wire splices and taps shall be made firm, and adequate to carry the full current rating of the respective wire without soldering and without perceptible temperature rise.

C. All splices shall be so made that they have an electrical resistance not in excess of two feet (600 mm) of the conductor.

D. Use solderless spring type pressure connectors with insulating covers for wire splices and taps, 10 AWG and smaller.

E. Use mechanical or compression connectors for wire splices and taps, 8 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor.

F. Thoroughly clean wires before installing lugs and connectors.

G. At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.

H. Protect wiring in device and junction boxes from paint overspray. Wiring covered with paint shall be removed and replaced where needed by the Contractor.

## 3.4 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 260504 Cleaning and Testing.

## 3.5 WIRE COLOR

A. For wire sizes 10 AWG and smaller - Wire shall be colored as indicated below.

B. For wire sizes 8 AWG and larger – Use colored wire, or identify wire with colored ½” or ¾” tape bands at all terminals, splices and boxes. Tape bands shall be installed at every 12” for the entire visible length. Colors to be as indicated below.

C. All wire must use the following color scheme:
   1. Phase A black, Phase B red and Phase C blue for circuits at 120/208 volts single or three phase.
   2. Phase A brown, Phase B orange and Phase C yellow for circuits at 277/480 volts single or three phase.
   3. Neutral Conductors: White for 120/208V systems, Gray for 277/480V systems. Where there are two or more neutrals in one conduit, each shall be individually identified with a different stripe.

4. Note: This includes fixture whips except for Listed whips mounted by the fixture manufacturer on the fixture and Listed as a System.

D. All switch legs shall be the same color as their associated circuit. Traveler conductors run between 3 and 4 way switches shall be colored pink or purple.

E. Ground Conductors: Green for 2 AWG and smaller. For 1 AWG and larger, identify with green colored wire, or with green tape at both ends and at all access points, such as panelboards, motor starters, disconnects and junction boxes.

F. More Than One Nominal Voltage System Within A Building: Permanently post the color coding scheme at each branch-circuit panelboard.

## 3.6 IDENTIFICATION

A. Identification Tags: Use tags to identify feeders and designated circuits. Install tags so that they are easily read without moving adjacent feeders or requiring removal of arc proofing tapes. Attach tags with non-ferrous wire or brass chain.
   1. Interior Feeders: Identify each feeder in pullboxes and gutters. Identify by feeder number and size.
   2. Exterior Feeders: Identify each feeder in handholes and in interior pullboxes and gutters. Identify by feeder number and size, and also indicate building number and panel designation from which feeder originates.
   3. Street and Grounds Lighting Circuits: Identify each circuit in handholes and lighting standard bases. Identify by circuit number and size, and also indicate building number and panel designation from which circuit originates.

B. Identification Plaque: Where a building or structure has any combination of feeders, branch circuits, or services passing through it, install a permanent plaque or directory at each service, feeder and branch circuit disconnect location denoting all other services, feeders, or branch circuits supplying that building or structure or passing through that building or structure and the area served by each. Minimum engraved plaque size of 8”x6”.

## 3.7 WIRE MANAGEMENT

A. Use wire management products to bundle, route, and support wiring in junction boxes, pullboxes, wireways, gutters, channels, and other locations where wiring is accessible.

## 3.8 BRANCH CIRCUITS

A. The use of single-phase, multi-wire branch circuits with a common neutral is not permitted. All branch circuits shall be furnished and installed with an individual accompanying neutral, sized the same as the phase conductors.

B. The use of a common neutral for modular furniture will be allowed with the following conditions:

1. (Three) 3-phase circuit breaker is used.
2. Neutral is sized 200% larger than phase conductor.

3.9 EMERGENCY CIRCUITS

A. All emergency system wiring (Level 1 and Level 2) shall be installed in separate raceways after their associated transfer switches. The wiring shall be separate from each other and from all normal system wiring.

**END OF SECTION**

**SECTION 260523**

**CONTROL CABLES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the required remote control and signal cabling indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

B. Section 260533 Raceway and Boxes.

C. Section 260553 Identification.

D. NFPA 70 National Electrical Code.

1.3 SUBMITTALS

A. Submit product data: Provide for each cable assembly type.

B. Submit manufacturer's installation instructions. Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.

1.4 PROJECT CONDITIONS

A. Verify that field measurements are as shown on Drawings.

B. Conductor sizes are based on copper.

C. All conductors shall be copper.

D. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.

E. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 - PRODUCTS

2.1 GENERAL

A. All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of manufacturer's stock.

B. All conductors shall be copper.

C. Insulation shall have a 600 volt rating.

D. All conductors must be suitable for the application intended. Conductors #12 and smaller may be solid or stranded with the following requirements or exceptions:
   1. All conductors terminated with crimp type devices must be stranded.
   2. Stranded conductors may only be terminated with UL OR ETL Listed type terminations or methods: e.g. stranded conductors may not be wrapped around a terminal screw but must be terminated with a crimp type device or must be terminated in an approved back wired method.

2.2 REMOTE CONTROL AND SIGNAL CABLE

A. Refer to Division 28 for requirements for cable to be used on safety and security systems.

B. Refer to Division 27 for requirements for cable to be used on communication systems.

C. All other systems cabling shall meet the requirements of NEC Article 725 and the following:
   1. Control Cable for Class 1 Remote Control and Signal Circuits: 600 volt insulation, individual conductors twisted together, shielded (where required), and covered with an overall PVC jacket.
      a. Cable shall be Listed, temperature rated, and plenum or non-plenum rated for the application as required in the National Electrical Code.
   2. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits shall be constructed, Listed, temperature rated, and plenum or non-plenum rated for the application as required in the NEC Article 725.

2.3 WIRING CONNECTORS

A. Split Bolt Connectors: Not acceptable.

B. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller.

C. All wire connectors used in underground or exterior pull boxes shall be gel filled twist connectors or a connector designed for damp and wet locations.

PART 3 - EXECUTION

3.1 GENERAL WIRING METHODS

A. Low voltage control and signal cables shall be installed in conduit. However, they may be installed without conduit above accessible ceilings if the cable meets NEC requirements for the application, unless specified to be in conduit in other sections of the specifications. See requirements for free-air cabling installation below.

B. Control cables for controlling HVAC and lighting equipment connected to emergency power shall be routed in raceway.

C. Do not use wire smaller than 14 AWG for control wiring greater than 60 volts, or 18 AWG for voltages less than 60 volts, all sizes subject to NEC 725 requirements.

D. Splice only in junction boxes.

E. Identify wire per section 260553.

F. Neatly train and lace wiring inside boxes, and equipment.

3.2 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

C. Completely and thoroughly swab raceway system before installing conductors.

D. Place all conductors of a given circuit (this includes phase wires, neutral (if any), and ground conductor in the same raceway.

3.3 FREE-AIR CABLE INSTALLATION

A. Free-air installation is allowed for low voltage cabling associated with the following systems:
   1. Fire alarm
   2. Technology cabling (where cable tray is not available)
   3. Control cables (DDC, digital lighting control system, etc.)

B. ‘Free-Air’ wiring runs shall avoid areas of high traffic (i.e. aisle way), open structure when possible, be run as close as possible to outlining walls and above accessible ceilings when possible.

C. Cabling shall be neatly run at right angles and be kept clear of other trades work.

D. Cabling shall be supported at a maximum of 4-foot intervals utilizing mounting bridal rings or J-hooks anchored to the wall, overhead structure, piping supports or structural steel beams. If cable sag at mid-span exceeds 12-inches, another support shall be provided. Fire alarm cabling shall be installed in a dedicated support system of J-hooks and/or bridal rings separate from all other low voltage cabling.

E. Mounting rings/hooks shall be designed to maintain cables bend to larger than the minimum bed radius (typically 4 x cable diameter).

F. Bundle cabling together, where possible, using Velcro straps. The use of zip ties for cable bundling is NOT allowed.

G. Cabling being routed above an inaccessible ceiling exceeding 6' in length shall be sleeved using raceway for ease of cable installation and replacement.

H. Cabling shall not be attached to or supported by other systems, including but not limited to: cabling, plumbing or piping, ductwork, suspended ceiling supports or electrical conduit. Additionally, cabling shall not be laid directly on the ceiling grid.

I. To reduce or eliminate Electro-Magnetic Interference (EMI), the following minimum separation distances for 'Free-Air' cabling installations shall be adhered to:
   1. Twelve (12) inches from power lines of less than 5kV.
   2. Eighteen (18) inches from lighting fixtures.
   3. Thirty-nine (39) inches from transformers and motors.

J. A coil of six (6) feet in each cable shall be placed in the ceiling at each 'free-air' wire device. These coils shall be secured (wire tied) at the last cable support before the cable reaches the device and shall be coiled from 100% to 200% of the cable recommended minimum bend radius.

K. All cable shall be free of tension at both ends. Nylon strain relief connectors shall be provided at each device and junction box where cables enter. In cases where the cable must bear some stress, Kellum type grips may be used to spread the strain over a longer length of cable.

L. Cable manufacturers minimum bend radius shall be observed in all instances. Care should be taken in the use of cable ties to secure and anchor the station cabling. Ties should not be over tightened as to compress the cable jacket. No sharp burrs should remain where excess length of the cable tie has been cut.

M. All exposed vertical cable extensions to devices located below the finished ceiling shall be in conduit.

N. Provide protection for exposed cables where subject to damage.

O. Use suitable cable fittings and connectors.

P. All cabling observed not meetnig the requirements indicated in the contract documents will be relocated at the contractors expense.

3.4 WIRING CONNECTIONS AND TERMINATIONS

A. Splice only in accessible junction boxes.

B. All splices shall be so made that they have an electrical resistance not in excess of two (2) feet (600 mm) of the conductor.

C. Use solderless spring type pressure connectors with insulating covers for wire splices and taps, 10 AWG and smaller.

D. Thoroughly clean wires before installing lugs and connectors.

E. At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.

F. Protect wiring in device and junction boxes from paint overspray. Wiring covered with paint shall be removed and replaced where needed by the Contractor.

3.5 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 260504.

**END OF SECTION**

**SECTION 260526**

**GROUNDING**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following grounding indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment included in this Section
   1. Grounding electrodes and conductors
   2. Equipment grounding conductors
   3. Bonding.

1.2 REFERENCES

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All design, materials, installation and testing pertaining to grounding and bonding system shall comply with the latest edition of applicable requirements and standards addressed within the following references:
   1. Applicable provisions of Division 1 govern work under this Section
   2. Section 260519 – Low Voltage Electrical Power Conductors and Cable
   3. Section 260800 – Commissioning of Electrical Systems
   4. Section 264113 –Lightning Protection for Structures
   5. NFPA 70 - National Electrical Code.
   6. NFPA 780 - Standard for the Installation of Lightning Protection Systems.
   7. ANSI/IEEE 142 (Latest edition) - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
   8. IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Ground System.
   9. IEEE 1100 - Recommended Practice for Powering and Grounding Electronic Equipment (IEEE Emerald Book).
   10. IEEE C2 - National Electrical Safety Code (NESC).
   11. UL 467 – Grounding and Bonding Equipment.
   12. LPI (Lightning Protection Institute) 175- Standard of Practice for the Design - Installation - Inspection of Lightning Protection Systems.
   13. UL 96 - Lightning Protection Components.
   14. UL 96A - Standard for Safety Installation Requirements for Lightning Protection Systems.

15. UL 497 - Protectors for Paired-Conductor Communications Circuits.
16. UL 497A - Secondary Protectors for Communications Circuits.
17. UL 497B - Protectors for Data Communications and Fire-Alarm Circuits
18. UL 1449 - Standard for Safety Surge Protective Devices
19. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition.
20. ANSI J-STD-607-A – Commercial Building Grounding and Bonding Requirements for Telecommunications.

## 1.3 SUBMITTALS

A. Product Data: Provide data for grounding electrodes and connections.

B. Manufacturer's Instructions: Include instructions for preparation, installation and examination of exothermic connectors.

## 1.4 QUALITY ASSURANCE

A. See Part 3 of this Specification for system requirements and performance requirements.

## 1.5 SUMMARY

A. Ground the electrical service system neutral at service entrance equipment to grounding grounding electrode system and the counterpoise loop. Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operations. Provide a completely grounded system in accordance with Article 250 of the NEC

B. Metal water piping system(s) installed in or attached to a building or structure shall be bonded to the service equipment enclosure, the grounded conductor at the service. Where installed in or attached to a building or structure, a metal piping system(s), including gas piping, that is likely to become energized shall be bonded to the service equipment enclosure, the grounded conductor at the service. The bonding jumper(s) shall be sized in accordance with Article 250 of the NEC.

C. Ground each separately-derived system neutral to separate ground buses that are installed in nearest electrical rooms. Transformers, inverters, or other power supplies are separately derived systems. Standby or emergency generators are separately derived systems if the neutral is bonded to the generator frame and if there is no direct connection of the generator neutral conductor to the service neutral conductor.

D. Concrete reinforcing bars shall be permitted for grounding. Connect the structural metal frame to the reinforcing bars of concrete-encased electrode. Concrete-encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system where the steel reinforcing bars or rods are not accessible for use without disturbing the concrete.

E. Provide communications system-grounding conductor at point of service entrance and connect to telecommunications grounding busbars. Bond together the communications system grounding.

F. Bond together system service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, metal cable trays, auxiliary gutters, meter fittings, boxes, cable armor, cable sheath, ground bus in electrical rooms, metal frame of the building or structure, ground ring, lightning down lead conductor, grounding conductor in raceways and cables, receptacle ground connectors, and metallic plumbing systems.

## 1.6 CERTIFICATIONS

A. Two (2) weeks prior to final inspection, submit four (4) copies of the following to the Engineer and General Contractor/Construction Manager:
   1. Certification that the materials and installation is in accordance with the drawings and specifications.
   2. Certification, by the Contractor, that the complete installation has been properly installed and tested.

## 1.7 CLOSEOUT SUBMITTAL AND PROJECT RECORD DOCUMENTS

A. Accurately record actual locations of grounding electrodes. Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.

B. Test Reports: Indicate overall resistance to ground and resistance of each electrode

# PART 2 - PRODUCTS

## 2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Grounding system components shall be as required to comply with the design and construction of the system indicated. Components shall be as indicated in manufacturer's submittal data.

## 2.2 ROD ELECTRODE

A. Material: Copper-clad steel.

B. Diameter: 3/4 inch minimum.

C. Length: Ten (10) feet minimum.

## 2.3 PLATE ELECTRODE

A. Copper plates minimum 0.06 inches thick by 2'-0" square feet of surface area.

## 2.4 MECHANICAL CONNECTORS

A. Products:
   1. Ground Clamps (Cable to Pipe):
      a. Blackburn/T&B Corp.'s GUV
      b. Framatome Connectors/Burndy Corp.'s GAR, GD, GP, GK
      c. OZ/Gedney Co.'s ABG, CG
   2. Ground Clamps (Cable to Rod):
      a. Blackburn/T&B Corp.'s GG, GGH, JAB, JABH, GUV
      b. Dossert Corp.'s GN, GPC
      c. Framatome Connectors/Burndy Corp.'s GP, GX, GRC
      d. OZ/Gedney Co.'s ABG
   3. Ground Lugs - Copper, one (1) or two (2) hole style (to suit conditions), long barrel:
      a. Anderson/Hubbell's VERSAtile VHCL
      b. Blackburn/T&B Corp.'s Color-Coded CTL, LCN
      c. Framatome Connectors/Burndy's Hylug YA
      d. Electrical Products Div./3M Scotchlok 31036 or 31145 Series
      e. Ideal Industries Inc.'s CCB or CCBL
      f. Thomas & Betts Corp.'s 54930BE or 54850BE Series

B. The mechanical connector bodies shall be manufactured from high strength, high conductivity cast copper alloy material. Bolts, nuts, washers and lockwashers shall be made of Silicon Bronze and supplied as a part of the connector body and shall be of the two bolt type.

C. Split bolt connector types are NOT allowed. Exception: the use of split bolts is acceptable for grounding of wire-basket type cable tray, and for cable shields/straps of medium voltage cable.

D. The connectors shall meet or exceed UL 467 and be clearly marked with the catalog number, conductor size and manufacturer.

## 2.5 COMPRESSION CONNECTORS

A. The compression connectors shall be manufactured from pure wrought copper.

B. The conductivity of this material shall be no less than 99% by IACS standards.

C. The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision.

D. The installation of the connectors shall be made with a compression, tool and die system, as recommended by the manufacturer of the connectors.

E. The connectors shall be clearly marked with the manufacturer, catalog number, conductor size and the required compression tool settings.

F. Each connector shall be factory filled with an oxide-inhibiting compound.

## 2.6 EXOTHERMIC CONNECTIONS

A. As manufactured by Erico (Cadweld), T&B (Furseweld) or similar.

## 2.7 GROUND CONDUCTORS

A. Material:
   1. Provide 600-volt insulated copper (aluminum not permitted) conductors having a green-colored insulation for grounding electrode and equipment grounding conductors. Use stranded conductors.
   2. Conduit grounding conductors shall be insulated copper conductor, green in color to size 2 AWG. Insulated conductors larger than 2 AWG shall be same as phase conductors but identified with green or green/yellow tape at each accessible opening or location in raceway.
   3. Provide bare conductors for bonding jumpers.
   4. Provide tinned copper conductors for exterior installations.
   5. Communications cable tray grounding conductors shall be a minimum of 6 AWG bare copper conductor.

B. Grounding Electrode Conductor: Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger.

C. Foundation Electrodes: As shown on drawings or details.

D. Feeder and Branch Circuit Equipment Ground: Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger. Differentiate between the normal ground and the isolated ground when both are used on the same facility.

## 2.8 GROUNDING BUSBAR

A. Where a field-provided ground bus or ground bar is required, use round-edge copper bar with 98 percent International Annealed Copper Standard (IACS) conductivity

B. Size the bus for not less than 25 percent of the cross-sectional areas of the related feeder. A minimum size of ¼-inch thick by 2-inch depth by 6-inch length (minimum) is required.
   1. The ground bar shall be a predrilled copper busbar provided with standard NEMA bolt hole sizing and spacing for the type of connectors to be used.
   2. The ground bar shall be tin-plated for reduced contact resistance.
   3. The ground bar shall be insulated from its support. A minimum of 2 inches separation is required. Mount the grounding busbars on insulated standoffs to ensure isolation from ground potential or stray potentials.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify that final backfill and compaction has been completed before driving rod electrodes.

## 3.2 GENERAL

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

B. Install grounding conductors continuous, without splice or connection, between equipment and grounding electrodes.

C. Size: When grounding and bonding conductors are not sized on Drawings, size the grounding conductors in accordance with NEC. Size bonding jumper so that minimum cross-sectional area is greater than or equal to that of the equivalent grounding conductor as determined from NEC.

D. Mechanical connections shall be accessible for inspection and checking. No insulation shall be installed over mechanical ground connections.

E. Ground connection surfaces shall be cleaned and all buried or inaccessible connections shall be made so that it is impossible to move them.

F. Attach grounds permanently before permanent building service is energized.

G. All grounding electrode conductors shall be installed in PVC conduit, in exposed locations.

## 3.3 LESS THAN 600 VOLT SYSTEM GROUNDING

A. System Grounding:
   1. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.
   2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.

B. Metallic Piping, Building Steel, and Supplemental Electrode(s)
   1. Provide 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. Jumper insulating joints in the metallic piping. All connections to electrodes shall be made with fittings that conform to UL 467.

C. Provide a supplemental ground electrode and bond to the grounding electrode system. Use driven ground rod(s) on exterior of building.

D. Service Disconnect (Separate Individual Enclosure): Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors

E. Switchboards:
   1. Connect the various feeder equipment grounding conductors to the ground bus in the enclosure with suitable pressure connectors.
   2. For service entrance equipment, connect the grounding electrode conductor to the ground bus.
   3. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and grounding conductor to the equipment ground bus.

F. Transformers:
   1. Exterior: Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.
   2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the nearest component of the grounding electrode system.

G. Equipment Grounding: Metallic structures (including ductwork and building steel), enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.

H. Conduit System:
   1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
   2. Non-metallic conduit systems shall contain an equipment grounding conductor, except that non-metallic feeder conduits which carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment need not contain an equipment grounding conductor.
   3. Install an insulated grounding conductor internally to all flexible metal conduits. All flexible metal conduit containing power circuits shall utilize grounding bushings. The grounding bushing shall contain a bonding jumper and shall be terminated at the equipment ground bus. The grounding conductor shall terminate at the equipment ground bus. Install external ground wire on liquid tight flexible metal conduit. Provide suitable grounding bushing at each end of liquid tight flexible metal conduit at transformers. External ground wire shall be in addition to grounding conductors installed internal to raceway system.
   4. Conduit containing only a grounding conductor, and which is provided for mechanical protection of the conductor, shall be bonded to that conductor at the entrance and exit from the conduit.

I. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders and power and lighting branch circuits.

J. Boxes, Cabinets, Enclosures, and Panelboards:
   1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes.
   2. Provide lugs in each box and enclosure for equipment grounding conductor termination.
   3. Provide ground bars in panelboards, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.

K. Motors and Starters: Provide lugs in motor terminal box and starter housing or motor control center compartment to terminate equipment grounding conductors.

L. Receptacles shall not be grounded through their mounting screws. Ground with a jumper from the receptacle green ground terminal to the device box ground screw and the branch circuit equipment grounding conductor.

M. Ground lighting fixtures to the equipment grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.

N. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.

## 3.4 CONDUCTIVE PIPING

A. Bond all conductive piping systems, interior and exterior, to the building to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

## 3.5 COMMUNICATIONS SYSTEM GROUNDING

A. Isolated (Single Point) Ground :
   1. Purpose:
      a. An isolated single point grounding system is employed for installations utilizing sensitive electronic, data processing or communications equipment.
      b. This single ground bus is not connected in electrical loops, but in a radial configuration between the various electronic equipment locations.
      c. The single ground bus is then connected to the building electrical service equipment ground. This grounding arrangement thus provides only a single path to ground for any circulating ground currents, which will minimize electromagnetic interference with sensitive electronic equipment.
   2. Equipment Requiring Isolated Grounding: Equipment typically grounded to the isolated single point grounding system includes communications and coaxial cable shields, telephone termination block earth grounds, radio transmitter chassis grounds, and electronic equipment signal grounds which are isolated from the equipment chassis.
   3. Grounding Busbars:
      a. Install a local isolated ground busbar in each room or area where indicated on the Drawings. Ground all sensitive electronic equipment in the room or area to the local isolated ground bus.
   4. Grounding Conductors:
      a. Conductors from individual equipment and cable shields shall be a minimum No. 6 AWG, type THW stranded copper with green insulation. The conductor from each local isolated ground bus to the service ground bus shall be a minimum of No. 2/0 AWG, or as indicated on the Drawings, type THW stranded copper with green insulation. The conductor from the service ground bus to the facility ground rod

array shall be a minimum of No. 2/0 AWG, type THW stranded copper with green insulation. Grounding cable with aluminum conductors is not acceptable. Leave 10 feet slack grounding conductor at each Telecommunications Room.

b. Conductors shall be routed to provide the minimum possible number of cable bends. The radius of any cable bend shall be not less than 8 inches, and the included angle of any bend shall be a minimum of 90 degrees.

c. The grounding conductor MUST NOT be attached to building steel (except as allowed at the main electrical service entrance).

5. Grounding Connections:

a. Connections from individual equipment and cable shields shall use crimp-type connectors of copper or tinned copper construction. Individual equipment connections to local isolated ground buses shall use copper alloy or bronze machine bolts and lock washers.

b. Paint-piercing grounding washers shall be used.

c. Connectors utilizing aluminum or steel alloys are not acceptable.

6. Connections to Isolated Grounding Systems: Use insulated equipment grounding conductor and connect only to service grounding electrode. Where isolated grounding system is associated with a separately derived system, bond isolated grounding conductor to system neutral at source of separately derived system in accordance with NEC.

B. General:

1. Route ground conductors to provide the shortest, most direct path from point to point. Telecommunications ground must be bonded to the lightning protection system grounding and may need additional bonding depending on: spacing, building dimensions, and construction.

2. Bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, the conductors shall be bonded to each end of the conduit with a conductor sized as a No. 6 AWG, minimum (this makes the conduit a parallel path with the cable). The connections of the bonding conductors for telecommunications shall utilize listed two-hole compression lugs.

3. A continuous ground path shall be provided in all telecommunications raceways. Grounded cable trays shall be considered continuous ground path.

4. Any grounding or bonding conductor that is run through a metallic conduit shall be bonded to the conduit.

5. Telecommunications primary protector grounding conductor shall be bonded to the ground bus in the room. A minimum of 1 foot separation shall be maintained between this insulated conductor and any DC power cables, switchboard cables, or high frequency cables, even when placed in metal raceway.

6. In buildings where the backbone telecommunications cabling incorporates a shield or metallic member, this shield or metallic member shall be bonded to the ground bus in the room where the cables are terminated or where pairs are broken out.

## 3.6 CORROSION INHIBITORS

A. 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.

## 3.7 LIGHTNING PROTECTION SYSTEM

A. Bond the lightning protection system to the electrical grounding electrode system.

## 3.8 ELECTRICAL ROOM GROUNDING

A. Building Earth Ground Busbars: Provide ground busbar hardware at each electrical room and connect to pigtail extensions of the building grounding ring.

## 3.9 WIREWAY GROUNDING

A. Grounding and Bonding Metallic Wireway Systems:
   1. Bond the metallic structures of wireway to provide 100 percent electrical continuity throughout the wireway system by connecting a 6 AWG bonding jumper at all intermediate metallic enclosures and across all section junctions.
   2. Install insulated 6 AWG bonding jumpers between the wireway system bonded as required in paragraph 1 above, and the closest building ground at each end and approximately every 50 feet.
   3. Use insulated 6 AWG bonding jumpers to ground or bond metallic wireway at each end at all intermediate metallic enclosures and cross all section junctions.
   4. Use insulated 6 AWG bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 50 feet.

## 3.10 GROUND ROD INSTALLATION

A. Drive each rod vertically in the earth, not less than 10 feet in depth.

B. Where permanently concealed ground connections are required, make the connections by the exothermic process to form solid metal joints. Make accessible ground connections with mechanical pressure type ground connectors.

C. Where rock prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified resistance.

## 3.11 GROUND RESISTANCE

A. Grounding system resistance to ground shall not exceed 5 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to the Owner. 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.

C. Services at power company interface points shall comply with the power company ground resistance requirements.

D. Engineer has the option to observe below-grade connections prior to backfilling. The Contractor shall notify the Engineer 24 hours before the connections are ready for observation.

3.12 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

**END OF SECTION**

**SECTION 260529**

**HANGERS AND SUPPORTS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following hangers and supports indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment included in this Section
   1. Conduit and equipment supports
   2. Straps
   3. Clamps
   4. Steel channel, etc.
   5. Fastening hardware for supporting electrical work.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

1.3 SUBMITTALS

A. Shop Drawings: Show support details if different from methods specified or shown on the drawings.

B. Product Data: Catalog sheets, specifications and installation instructions.

1.4 QUALITY ASSURANCE

A. Support systems shall be adequate for the weight of equipment and conduit, including wiring, which they carry.

PART 2 - PRODUCTS

2.1 ANCHORING DEVICES

A. Sleeve Anchors
   1. Molly/Emhart’s Parasleeve Series
   2. Phillips’ Red Head Dynabolt Series
   3. Ramset’s Dynabolt Series

B. Wedge Anchors
   1. Hilti's Kwik Bolt Series
   2. Molly/Emhart's Parabolt Series
   3. Phillips' Red Head Trubolt
   4. Ramset's Trubolt Series

C. Concrete Screw Anchors
   1. Phillips' Red Head Tapcon

D. Non-Drilling Anchors
   1. Hilti's Drop-In Anchor Series
   2. Phillips' Red Head Multi-Set II Series
   3. Ramset's Dynaset Series

E. Stud Anchors
   1. Phillips' Red Head JS Series

## 2.2 CAST-IN-PLACE CONCRETE INSERTS

A. Continuous Slotted Type Concrete Insert, Galvanized:
   1. Load Rating 1300 lbs./ft.: Kindorf's D-986
   2. Load Rating 2400 lbs./ft.: Kindorf's D-980
   3. Load Rating 3000 lbs./ft.: Hohmann & Barnard Inc.'s Type CS-H
   4. Load Rating 4500 lbs./ft.: Hohmann & Barnard Inc.'s Type CS-HD

B. Threaded Type Concrete Insert: Galvanized ferrous castings, internally threaded.

C. Wedge Type Concrete Insert: Galvanized box-type ferrous castings, designed to accept bolts having special wedge shaped heads.

## 2.3 HAMMER SET ANCHOR

A. Zinc plated steel drive pin with expanding alloy body:
   1. Phillips' Red Head HS Series
   2. Hilti HIT Series
   3. Ramset Shuredrive Series

## 2.4 MISCELLANEOUS FASTENERS

A. Except where shown otherwise on the Drawings, furnish fastener type, size, and grade required for proper installation of the Work. Select from the following:
   1. Cadmium or Zinc Coated Fasteners: Dry locations.
   2. Galvanized Fasteners: For exterior use, or for items anchored to exterior walls, except where stainless steel is indicated.
   3. Stainless Steel Fasteners: Type 302 for interior Work; Type 316 for exterior Work; Phillips head screws and bolts for exposed Work unless otherwise specified.

2.5 HANGER RODS

A. Mild low carbon steel, unless otherwise specified; fully threaded or threaded each end, with nuts as required to position and lock rod in place. Unless galvanized or cadmium plated, provide a shop coat of red lead or zinc chromate primer paint.

B. Minimum sized threaded rod for supports shall be 3/8" for trapezes and single conduits 1-1/4" and larger, and 1/4" for single conduits 1" and smaller.

2.6 "C" BEAM CLAMPS

A. With Conduit Hangers
   1. For 1 Inch Conduit Maximum:
      a. B-Line Systems Inc.'s BG-8, BP-8 Series
      b. Caddy/Erico Products Inc.'s BC-8P and BC-8PSM Series
      c. GB Electrical Inc.'s HIT 110-412 Series
   2. For 3 Inch Conduit Maximum:
      a. Appleton Electric Co.'s BH-500 Series beam clamp with H50W/B Series hangers
      b. Kindorf's 500 Series beam clamp with 6HO-B Series hanger
      c. OZ/Gedney Co.'s IS-500 Series beam clamp with H-OWB Series hanger
   3. For 4 Inch Conduit Maximum:
      a. Kindorf's E-231 beam clamp and E-234 anchor clip and C-149 series lay-in hanger
      b. Unistrut Corp.'s P2676 beam clamp and P-1659A Series anchor clip with J1205 Series lay in hanger

B. For Hanger Rods
   1. For 1/4 Inch Hanger Rods:
      a. B-Line Systems Inc.'s BC
      b. Caddy/Erico Products Inc.'s BC
      c. GB Electrical Inc.'s HIT 110
      d. Kindorf's 500, 510
      e. Unistrut Corp.'s P1648S, P2398S, P2675, P2676
   2. For 3/8 Inch Hanger Rods:
      a. Caddy/Erico Products Inc.'s BC
      b. Kindorf's 231-3/8, 502
      c. Unistrut Corp.'s P1649AS, P2401S, P2675, P2676
   3. For 1/2 Inch Rods:
      a. Appleton Electric Co. BH-500 Series
      b. Kindorf's 500 Series, 231-1/2
      c. OZ/Gedney Co.'s IS-500 Series
      d. Unistrut Corp.'s P1650AS, P2403S, P2676
   4. For 5/8 Inch Rods: Unistrut Corp.'s P1651AS beam clamp and P1656A Series anchor clip.
   5. For 3/4 Inch Rods: Unistrut Corp.'s P1653S beam clamp and P1656A Series anchor clip.

2.7 CHANNEL SUPPORT SYSTEM

A. Channel Material: 12 gauge steel.

B. Finishes
   1. Phosphate and baked green enamel/epoxy.
   2. Pre-galvanized.
   3. Electro-galvanized.
   4. Hot dipped galvanized.
   5. Polyvinyl chloride (PVC), minimum 15 mils thick.

C. Fittings: Same material and finish as channel.

D. UL Listed Systems
   1. B-Line Systems Inc.'s B-22 (1-5/8 x 1-5/8 inches), B-12 (1-5/8 x 2-7/16 inches), B-11 (1-5/8 x 3-1/4 inches).
   2. Grinell Corp.'s Allied Power-Strut PS 200 (1-5/8 x 1-5/8 inches), PS 150 (1-5/8 x 2-7/16 inches), PS 100 (1-5/8 x 3-1/4 inches).
   3. Kindorf's B-900 (1-1/2 x 1-1/2 inches), B-901 (1-1/2 x 1-7/8 inches), B-902 (1-1/2 x 3 inches).
   4. Unistrut Corp.'s P-3000 (1-3/8 x 1-5/8 inches), P-5500 (1-5/8 x 2-7/16 inches), P-5000 (1-5/8 x 3-1/4 inches).
   5. Versabar Corp.'s VA-1 (1-5/8 x 1-5/8 inches), VA-3 (1-5/8 x 2-1/2 inches).

## 2.8 MISCELLANEOUS FITTINGS

A. Side Beam Brackets
   1. B-Line Systems Inc.'s B102, B103, B371-2
   2. Kindorf's B-915
   3. Versabar Corp.'s VF-2305, VF-2507

B. Pipe Straps (Heavy Duty Type):
   1. Two (2) Hole Steel Conduit Straps:
      a. B-Line Systems Inc.'s B-2100 Series
      b. Kindorf's C-144 Series
      c. Unistrut Corp.'s P-2558 Series
   2. One (1) Hole Malleable Iron Clamps:
      a. Kindorf's HS-400 Series
      b. OZ/ Gedney Co.'s 14-G Series, 15-G Series (EMT)

C. Deck Clamps: Caddy/Erico Products Inc.

D. Supporting Fittings for Pendent Mounted LED Fixtures on Exposed Conduit System:
   1. Ball Hanger: Appleton Electric Co.'s AL Series, or Crouse-Hinds Co.'s AL Series
   2. Flexible Fixture Hanger: Appleton Electric Co.'s UNJ-50, UNJ-75, or Crouse-Hinds Co.'s UNJ115
   3. Flexible (Hook Type) Fixture Hanger: Appleton Electric Co.'s FHHF, or Crouse-Hinds Co.'s UNH-1
   4. Eyelet: Unistrut Corp.'s M2250
   5. Eyelet with Stud: Kindorf's H262, or Unistrut Corp.'s M2350

6. Conduit Hook: Appleton Electric Co.'s FHSN, or Crouse-Hinds Co.'s UNH-13

E. Supporting Fasteners (Metal Stud Construction): Metal stud supports, clips and accessories as produced by Caddy/Erico Products Inc.

## 2.9 ROOFTOP SUPPORT SYSTEMS

A. Rooftop supports for conduit, cable tray or equipment shall be provided for installation without requiring roof penetrations, flashing or damage to the roofing material. Height-adjustable supports may be used where necessary. Support conduit a minimum of 4' above the roof surface.

B. Materials:
1. Support bases shall be made of an engineered material with appropriate additives for UV protection. All structural steel components shall be hot-dipped galvanized.
2. The support shall have a continuous bottom surface to provide even load distribution and minimize point loading of the roof membrane. The support base will have a radiused edge to enhance compatibility with roof membranes.
3. Coordinate static load rating of the support(s) with the specific application being served.
4. Accessories: Clamps, bolts, nuts, washers, and other devices as required for a complete system.

C. Applications:
1. Fixed Strut Supports: Size and load ratings for the application
2. Adjustable Strut Supports: Height adjustable, size and load ratings for the application
3. Adjustable Single Conduit Supports: Height adjustable, size and load ratings for the application
4. Bridge Assemblies:
   a. Suitable for multiple conduit runs, cable tray or equipment
   b. Size and load ratings for the application
5. Post Base Assemblies:
   a. For use with vertical sections of channel support systems
   b. Size, channel support configuration, and load ratings for the application
6. Manufacturers:
   a. Caddy/Pentair, Cooper B-Line, Mifab, Arlington, Rooftop Blox, Haydon, MAPA Products

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Where specific fasteners are not specified or indicated for securing items to in-place construction, provide appropriate type, size, and number of fasteners for a secure, rigid installation.

B. Install anchoring devices and other fasteners in accordance with manufacturer's printed instructions.

C. Make attachments to structural steel wherever possible.

## 3.2 FASTENER SCHEDULE

A. Material
   1. Use cadmium or zinc coated anchors and fasteners in dry locations.
   2. Use hot dipped galvanized or stainless steel anchors and fasteners in damp and wet locations.
   3. For corrosive atmospheres or other extreme environmental conditions, use fasteners made of materials suitable for the conditions.

B. Types and Use: Unless otherwise specified or indicated use:
   1. Cast-in-place concrete inserts in fresh concrete construction for direct pull-out loads such as shelf angles or fabricated metal items and supports attached to concrete slab ceilings.
   2. Anchoring devices to fasten items to solid masonry and concrete when the anchor is not subjected to pull out loads, or vibration in shear loads.
   3. Toggle bolts to fasten items to hollow masonry and stud partitions.
   4. Metallic fasteners installed with electrically operated or powder driven tools for approved applications, except:
      a. Do not use powder driven drive pins or expansion nails.
      b. Do not attach powder driven or welded studs to structural steel less than 3/16 inch thick.
      c. Do not support a load, in excess of 250 lbs from any single welded or powder driven stud.
      d. Do not use powder driven fasteners in precast concrete
   5. Metallic hammer set anchors may be used in wall and ceiling applications. Maximum conduit size supported with hammer set anchors is 1 Inch.

## 3.3 ATTACHMENT SCHEDULE

A. General: Make attachments to structural steel or steel bar joists wherever possible. Provide intermediate structural steel members where required by support spacing. Select steel members for use as intermediate supports based on a minimum safety factor of 5.
   1. Make attachments to steel bar joists at panel points of joists.
   2. Do not drill holes in main structural steel members.
   3. Use "C" beam clamps for attachment to steel beams.

B. Where it is not possible to make attachments to structural steel or steel bar joists, use the following methods of attachment to suit type of construction unless otherwise specified or indicated on the drawings.
   1. Attachment to Steel Roof Decking (No Concrete Fill):
      a. Decking With Hanger Tabs: Use deck clamps.
      b. Decking Without Hanger Tabs:

1) Before Roofing Has Been Applied: Use 3/8 inch threaded steel rod welded to a 4 x 4 x 1/4 inch steel plate and installed through 1/2 inch hole in roof deck.
2) After Roofing Has Been Applied: Use welding studs, or self-drilling/tapping fasteners. Exercise extreme care when installing fasteners to avoid damage to roofing.

2. Attachment to Concrete Filled Steel Decks (Total thickness, 2-1/2 inches or more):
   a. Before Fill Has Been Placed:
      1) Use thru-bolts and fish plates.
      2) Use welded studs. Do not support a load in excess of 250 pounds from a single welded stud.
   b. After Fill Has Been Placed: Use welded studs. Do not support a load in excess of 250 lbs from a single welded stud.
3. Attachment to Cast-In-Place Concrete:
   a. Fresh Concrete: Use cast-in-place concrete inserts.
   b. Existing Concrete: Use anchoring devices.
4. Attachment to Cored Precast Concrete Decks:
   a. New Construction: Use thru-bolts and fish plates before Construction Work Contractor has placed concrete fill over decks.
   ~~b. Existing Construction: Toggle bolts may be installed in cells for a maximum load of _____.~~
5. Attachment to Hollow Block or Tile Filled Concrete Deck:
   a. New Construction: Use cast-in-place concrete inserts by having Construction Work Contractor omitting blocks and pouring solid blocks with insert where required.
6. Attachment to Waffle Type Concrete Decks:
   a. New Construction:
      1) Use cast-in-place concrete inserts in fresh concrete.
      2) If concrete fill has been applied over deck, thru-bolts and fish plates may be used where additional concrete or roofing is to be placed over the deck.
7. Attachment to Precast Concrete Planks: Use anchoring devices, except do not make attachments to precast concrete planks less than 2-3/4 inches thick.
8. Attachment to Precast Concrete Tee Construction:
   a. New Construction:
      1) Use tee hanger inserts between adjacent flanges.
      2) Use thru-bolts and fish plates, except at roof deck without concrete fill.
   b. Do not use powder driven fasteners.
   c. Exercise extreme care in drilling holes to avoid damage to reinforcement.

9. Attachment to Metal Stud Construction: Use supporting fasteners manufactured specifically for the attachment of raceways and boxes to metal stud construction.
   a. Support and attach outlet boxes so that they cannot torque/twist by using one of the following:
      1) Bar hanger assembly.
      2) Box hanger with far side support.
      3) Between stud mounting bracket.

## 3.4 CONDUIT SUPPORT SCHEDULE

A. Provide number of supports as required by National Electrical Code.

B. Use pipe straps and specified method of attachment where conduit is installed proximate to surface of wood or masonry construction.
   1. Use hangers secured to surface with specified method of attachment where conduit is suspended from the surface.

C. Use “C” beam clamps and hangers where conduit is supported from steel beams.

D. Use deck clamps and hangers where conduit is supported from steel decking having hanger tabs.
   1. Where conduit is supported from steel decking that does not have hanger tabs, use clamps and hangers secured to decking, utilizing specified method of attachment.

E. Use channel support system supported from structural steel for multiple parallel conduit runs.

F. Where conduits are installed above ceiling, do not rest conduit directly on runner bars, T-Bars, etc.
   1. Conduit Sizes 2-1/2 Inches and Smaller: Support conduit from ceiling supports or from construction above ceiling.
   2. Conduit Sizes Over 2-1/2 Inches: Support conduit from concrete deck, beams, joists, or trusses above ceiling.

## 3.5 LIGHTING FIXTURE SUPPORT SCHEDULE

A. General: Do not support fixtures from ceilings or ceiling supports unless it is specified or indicated on the drawings to do so.
   1. Support fixtures with hanger rods attached to beams, joists, or trusses. Hanger rod diameter, largest standard size that will fit in mounting holes of fixture.
      a. Where approved, channel supports may span and rest upon the lower chord of trusses and be utilized for the support of lighting fixtures.
      b. Where approved, channel supports may span and be attached to the underside of beams, joists, or trusses and be utilized for the support of lighting fixtures.
   2. Use two (2) nuts and two (2) washers on lower end of each hanger rod to hold and adjust fixture (one (1) nut and washer above top of fixture housing, one (1) nut and washer below top of fixture housing).
      a. Where specified that an adequately supported outlet box is to support a fixture or be utilized as one (1) point of support, support the box so that it may be adjusted to bring the face of the outlet box even with surface of ceiling

B. Specific Installations Where Fixtures May Be Supported From New Ceilings Being Installed by the General Contractor:
   1. Support recessed mounted fixtures directly from furring members of furred gypsum board ceilings.

2. Support recessed mounted fixtures directly from the suspension system of suspended acoustical ceilings. Exception: Support each fixture weighing more than 50 pounds independent of the suspended ceiling grid.
3. Deliver documents that state actual fixture weights and indicate fixture locations to the General Contractor/Construction Manager.

C. Number of Supports for Ceiling Mounted Lighting Fixtures: Provide at least the following number of supports. Provide additional supports when recommended by fixture manufacturer, or shown on the drawings.
   1. Commercial and Industrial LED Fixtures:
      a. Support individual fixtures less than two (2) feet wide at two (2) points.
      b. Support continuous row fixtures less than two (2) feet wide at points equal to the number of fixtures plus one (1). Uniformly distribute the points of support over the row of fixtures.
      c. Support individual fixtures two (2) feet or wider at four (4) corners.
      d. Support continuous row fixtures two (2) feet or wider at points equal to twice the number of fixtures plus two (2). Uniformly distribute the points of support over the row of fixtures.
      e. An adequately supported outlet box may be utilized as one point of support for fixtures weighing less than 50 pounds.
   2. Vandal Resistant and Minimum Security LED Fixtures:
      a. Support individual fixtures less than two (2) feet wide at four (4) corners.
      b. Support continuous row fixtures less than two (2) feet wide at points equal to twice the number of fixtures. Uniformly distribute the points of support.
      c. Support individual fixtures two (2) feet or wider at each corner and one (1) support midway along each side of longest axis (six (6) supports total).
      d. Support continuous row fixtures two (2) feet or wider at points equal to four (4) times the number of fixtures. Uniformly distribute the points of support.
      e. An adequately supported outlet box may be utilized as one (1) point of support for fixtures weighing less than 50 pounds.
   3. Medium Security LED Fixtures: Support each fixture at minimum of six (6) points (each corner and midway along each side of longest axis). Outlet box shall not be counted as a point of support.
   4. Maximum Security LED Fixtures: Support each fixture at minimum of eight (8) points (each corner and two (2) supports spaced equally along each side of longest axis). Outlet box shall not be counted as a point of support.

D. Number of Supports for Wall Mounted Lighting Fixtures: Provide at least the following number of supports. Provide additional supports when recommended by fixture manufacturer, or shown on the drawings.
   1. Commercial and Industrial LED Fixtures:
      a. Support individual fixtures two (2) feet long or less at two (2) points.
      b. Support individual fixtures over two (2) feet long at three (3) points.
      c. Support continuous row fixtures at points equal to twice the number of fixtures. Uniformly distribute the points of support.
      d. An adequately supported outlet box may be utilized as one (1) point of support for fixtures weighing less than 50 pounds.
   2. Vandal Resistant and Minimum Security LED Fixtures:

a. Support individual fixtures two (2) feet long or less at minimum of four (4) points (each corner).
b. Support individual fixtures over two (2) feet long, to three (3) feet long, at minimum of six (6) points (each corner and midway along each side of longest axis).
c. Support continuous row fixtures at points equal to six (6) times the number of fixtures. Uniformly distribute the points of support.
d. An adequately supported outlet box may be utilized as one (1) point of support for fixtures weighing less than 50 pounds.

3. Medium Security and Maximum Security LED Fixtures:
   a. Support each fixture two (2) feet long or less at minimum of four (4) points (each corner).
   b. Support each fixture over two (2) feet long, to three (3) feet long, at minimum of six (6) points (each corner and midway along each side of longest axis).
   c. Support each fixture over three (3) feet long, to eight (8) feet long, at minimum of eight (8) points (each corner and two (2) supports spaced equally along each side of longest axis).
   d. Outlet box shall not be counted as a point of support.

## 3.6 CHANNEL SUPPORT SYSTEM SCHEDULE

A. Use channel support system where specified or indicated on the drawings.

B. Channel supports may be used, as approved, to accommodate mounting of equipment.

C. Material and Finish:
   1. Dry Locations: Use 12 gauge steel channel support system having any one of the specified finishes.
   2. Damp Locations: Use 12 gauge steel channel support system having any one of the specified finishes except green epoxy/enamel.
   3. Wet locations: Use 12 gauge steel channel support system having hot dipped galvanized, or PVC finish.

## 3.7 ROOFTOP SUPPORT SYSTEM

A. Install in accordance with manufacturer’s instructions and recommendations.

B. Provide complete and adequate support of all conduit, cable tray, or equipment.

C. The use of wood blocks for supporting conduit, cable tray, or equipment is not permitted.

D. If gravel top roof, gravel must be removed around and under support.

E. Consult roofing manufacturer for roof membrane compression capacities. If necessary, a compatible sheet of roofing material (isolation pad) may be installed under rooftop support to disperse concentrated loads and add further membrane protection.

F. Use properly sized clamps to secure conduit, cable tray, or equipment.

**END OF SECTION**

**SECTION 260533**

**RACEWAYS AND BOXES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following conduits, surface raceways, multi-outlet assemblies, auxiliary gutters, wall duct, and boxes for electrical systems including wall and ceiling outlet boxes, floor boxes, and junction boxes.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this section.

B. Section 260529 – Hangers and Supports.

C. Section 262726 – Wiring Devices.

D. Section 262702 – Equipment Wiring.

E. Section 270000 – Communications Cable and Equipment.

F. Section 283100 – Fire Detection and Alarm.

1.3 SUBMITTALS

A. Floor Boxes: Provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.

PART 2 - PRODUCTS

2.1 RIGID METAL CONDUIT AND FITTINGS

A. Conduit: Heavy wall, galvanized steel, schedule 40, threaded.

B. Fittings and Conduit Bodies: Use all steel threaded fittings and conduit bodies.

2.2 INTERMEDIATE METAL CONDUIT (IMC) AND FITTINGS

A. Conduit: Galvanized steel, threaded.

B. Fittings and Conduit Bodies: Use all steel threaded fittings and conduit bodies.

## 2.3 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Conduit: Steel, galvanized tubing.
   1. Provide factory colored conduit as follows:
      a. Red – Fire alarm
      b. Blue – Low voltage
      c. Orange – Access control/security
      d. Green – Temperature controls

B. Fittings:
   1. All steel, set screw, concrete tight. No push-on or indenter types permitted.
   2. Raintight Fittings:
      a. All steel construction with zinc electroplate finish provides for durable corrosion resistance
      b. Distinct color to provide quick raintight identification
      c. Integral gasketed compression ring secures and seals for reliable installation
      d. Gasket on male threads of box connector seals installation for raintight connection between the box and the connector

C. Conduit Bodies: All steel threaded conduit bodies.

## 2.4 FLEXIBLE METAL CONDUIT AND FITTINGS

A. Conduit: steel, galvanized, spiral strip.

B. Fittings and Conduit Bodies: All steel, galvanized, or malleable iron (except as allowed in Specification 265113).

## 2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT AND FITTINGS

A. Conduit: flexible, steel, galvanized, spiral strip with an outer Liquidtight, nonmetallic, sunlight-resistant jacket.

B. Fittings and Conduit Bodies: ANSI/NEMA FB 1, compression type. There shall be a metallic cover/insert on the end of the conduit inside the connector housing to seal the cut conduit end.

## 2.6 RIGID NONMETALLIC CONDUIT AND FITTINGS

A. Conduit: Schedule 40 PVC minimum, Listed, sunlight resistant, rated for 90° C conductors.

B. Fittings and Conduit Bodies: NEMA TC 2, Listed.

2.7 HIGH DENSITY POLYETHYLENE

A. Minimum Size: Two (2) inch, unless noted otherwise

B. Acceptable Manufacturers
   1. Carlon
   2. Chevron Phillips Chemical Company
   3. Approved equal

C. Materials used for the manufacture of polyethylene pipe and fittings shall be extra high molecular weight, high-density polyethylene resin. The material shall be listed by PPI (Plastic Pipe Institute).

D. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same raw material, including both the base resin and coextruded resin. The pipe shall be homogeneous throughout and free of visible cracks, holes, voids, foreign inclusions, or other defects that may affect the wall integrity.

2.8 HDPE FITTINGS AND CONDUIT BODIES:

A. Directional Bore and Plow Type Installation: Electrofusion or Universal Aluminum threaded couplings. Tensile strength of coupled pipe must be greater than 2,000 lbs.

B. For all other type of installation: Coupler must provide a watertight connection. The tensile strength of coupled pipe must be greater than 1,000 lbs.

C. E-loc type couplings are not acceptable in any situations.

2.9 CONDUIT SUPPORTS

A. See Section 260529.

2.10 AUXILIARY GUTTERS (Wireways)

A. Description: General purpose Oil-tight and dust- tight type wireway without knockouts.

B. Size: As indicated on Drawings; length as indicated on Drawings.

C. Cover: Hinged cover with full gasketing.

D. Connector: Slip-in construction; hinged cover.

E. Fittings: Lay-in type with removable top, bottom, and side; captive screws.

F. Finish: Rust inhibiting primer coat with gray enamel finish.

## 2.11 OUTLET BOXES

A. Sheet Metal Outlet Boxes: galvanized steel, with stamped knockouts.

B. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 3/8 inch male fixture studs where required.

C. Concrete Ceiling Boxes: Concrete type.

D. Cast Boxes: Cast ferroalloy, or aluminum type deep type, gasketed cover, threaded hubs.

## 2.12 FLOOR BOXES

A. Floor Boxes for Installation in Cast-In-Place Concrete Floors: Full adjustable, formed steel.

B. Formed steel boxes in slab-on-grade applications shall be epoxy coated.

## 2.13 PULL AND JUNCTION BOXES

A. Pull boxes and junction boxes shall be minimum 4 inch square by 2 1/8th inches deep for use with 1 inch conduit and smaller. On conduit systems using 1 1/4 inch conduit or larger, pull and junction boxes shall be sized per NEC but not less than 4 11/16 inch square.

B. For telecommunication, fiber optic, security, and other low voltage cable installations the NEC box size requirements shall apply. All boxes, used on telecommunication, security, other low voltage and fiber optic systems with conduits of 1 1/4" and larger, shall be sized per the NEC conduit requirements. For determining box size, the conduit is the determining factor not the wire size.

C. Sheet Metal Boxes: code gauge galvanized steel, screw covers, flanged and spot welded joints and corners.

D. Sheet metal boxes larger than twenty-four (24) inches in any dimension shall have a hinged cover or a chain installed between box and cover.

E. Cast Metal Boxes for Outdoor and Wet Location Installations: Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as raintight. Galvanized cast iron or aluminum box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

F. Fiberglass or Concrete Handholes:
   1. With weatherproof cover of non-skid finish shall be used for underground installations.
   2. Size, type, weight rating, and labeling shall be as noted on the drawings.

G. The use of box extension rings is discouraged. If they must be used only one ring per box is allowed and wiring must extend a minimum of 6" beyond the front edge of the extension ring.

H. Box extensions and adjacent boxes within 48” of each other are not allowed for the purpose of creating more wire capacity.

I. Junction boxes 6" x 6" or larger size shall be without stamped knock-outs.

J. Wireways shall not be used in lieu of junction boxes.

2.14 GENERAL

A. All steel fittings and conduit bodies shall be galvanized.

B. No cast metal or split-gland type fittings permitted.

C. Mogul-type condulets larger than two inches (2”) not permitted except as approved or detailed.

D. All condulet covers must be fastened to the condulet body with screws and be of the same manufacture.

E. Wireways, gutters and c-condulets shall not be used in lieu of pull boxes and condulets.

F. All boxes shall be of sufficient size to provide free space for all conductors enclosed in the box and shall comply with NEC requirements.

PART 3 - EXECUTION

3.1 CONDUIT SIZING, ARRANGEMENT, AND SUPPORT

A. EMT is permitted to be used in sizes 4" and smaller for power and telecommunication systems. See CONDUIT INSTALLATION SCHEDULE below for other limitations for EMT and other types of conduit.

B. Size power conductor raceways for conductor type installed. Conduit size shall be 1/2 inch minimum except all homerun conduits shall be 3/4”, or as specified elsewhere. Caution: Per the NEC, the allowable conductor ampacity is reduced when more than three (3) current-carrying conductors are installed in a raceway. Contractor must take the NEC ampacity adjustment factors into account when sizing the raceway and wiring system.

C. Size conduit for all other wiring, including but not limited to data, control, security, fire alarm, telecommunications, signal, video, etc. shall be sized per number of conductors pulled and their cross-section. 40% fill shall be maximum for all new conduit fills.

D. Arrange conduit to maintain headroom and present a neat appearance.

E. Route exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent piping.

F. Maintain minimum six (6) inch clearance between conduit and piping. Maintain twelve (12) inch clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.

G. Arrange conduit supports to prevent distortion of alignment by wire pulling operations. Fasten conduit using galvanized pipe straps, conduit racks (lay-in adjustable hangers), clevis hangers, or bolted split stamped galvanized hangers.

H. Group conduit in parallel runs where practical and use conduit rack (lay-in adjustable hangers) constructed of steel channel with conduit straps or clamps. Provide space for 25 percent additional conduit.

I. Do not fasten conduit with wire or perforated pipe straps. Before conductors are pulled, remove all wire used for temporary conduit support during construction.

J. Support and fasten metal conduit at a maximum of eight (8) feet on center.

K. Supports shall be independent of the installations of other trades, e.g. ceiling support wires, HVAC pipes, other conduits, etc., unless so approved or detailed.

L. In general, all conduits shall be concealed except where noted on the drawings or approved by the Architect/Engineer. Contractor shall verify with Architect/Engineer all surface conduit installations except in mechanical, electrical or utility rooms that are not occupied spaces.

M. Changes in direction shall be made with symmetrical bends, cast steel boxes, stamped metal boxes or cast steel conduit bodies.

N. For indoor conduits, no continuous conduit run shall exceed 100 feet without a junction box.

O. All conduits installed in exposed areas shall be installed with a box offset before entering box.

## 3.2 CONDUIT INSTALLATION

A. Ground and bond conduit under provisions of Section 260526.

B. Cut conduit square; de-burr cut ends.

C. Conduit shall not be fastened to the corrugated metal roof deck. Maintain a minimum six (6) inch separation from the roof deck to conduits.

D. Bring conduit to the shoulder of fittings and couplings and fasten securely.

E. Use conduit hubs for fastening conduit to cast boxes. Use sealing locknuts or conduit hubs for fastening conduit to sheet metal boxes in damp or wet locations.

F. All conduit terminations (except for terminations into conduit bodies) shall use conduit hubs, or connectors with one (1) locknut, or shall use double locknuts (one (1) each side of box wall) and insulated bushing. Provide bushings for the ends of all conduit not terminated in box walls.

Refer to Section 260526 – Grounding and Bonding for Electrical Systems for grounding bushing requirements.

G. Install no more than the equivalent of four (4) 90 degree bends between boxes.

H. Use hydraulic one (1)-shot conduit bender or factory elbows for bends in conduit larger than two (2) inch size unless sweep elbows are required.

I. Conduit shall be bent according to manufacturers' recommendations. Torches or open flame shall not be used to aid in bend of PVC conduit.

J. Use suitable conduit caps or other approved seals to protect installed conduit against entrance of dirt and moisture.

K. Provide 1/8 inch nylon pull string in empty conduit, except sleeves and nipples.

L. Install expansion-deflection joints where conduit crosses building expansion joints. Note: expansion-deflection joints are not required where conduit crosses building control joints if the control joint does not act as an expansion joint. Install expansion fitting in PVC conduit runs as recommended by the manufacturer.

M. Avoid moisture traps where possible. Where moisture traps are unavoidable, provide junction boxes with drain fittings at conduit low points.

N. Where conduit passes between areas of differing temperatures such as into or out of cool rooms, unheated and heated spaces, buildings, etc., provide Listed conduit seals to prevent the passage of moisture and water vapor through the conduit.

O. Route conduit through roof openings for piping and ductwork where possible.

P. Conduit is not permitted in any slab topping of two inches or less. Consult Structural Engineer for approval of conduit installed in topping slabs greater than two inches.

Q. Maximum Size Conduit in Slabs Above Grade: 3/4 inch. Do not route conduits to cross each other in slabs above grade.

R. PVC conduit shall transition to galvanized rigid metal conduit before it enters a concrete pole base, foundation, wall (where exposed) or up through a concrete floor.

S. Identify conduit under provisions of Section 260553.

T. All conduit installed underground (exterior to building) shall be buried a minimum of 24" below finished grade, whether or not the conduit is concrete encased.
   1. All underground conduits shall be installed with "DANGER – BURIED ELECTRICAL CONDUIT" red flagging tape 6-inches above conduit. Tape shall be continuous along the conduit run.
   2. Tracer wire shall be installed on all exterior electrical utilities. Trace wire to be fourteen (14) gauge minimum solid copper with thermoplastic insulation recommended for direct burial. Wire connectors to be 3M DBR, or approved equal, and shall be watertight to

provide electrical continuity. Install trace wire in the same trench with the conduit during installation and secure to conduit as required to ensure that the wire remains adjacent to the conduit. Trace wire access points shall in general be no more than 500' apart.

U. PVC conduit shall be cleaned with solvent, and dried before application of glue. The temperature rating of glue/cement shall match weather condition. Apply full even coat of cement/glue to entire area that will be inserted into fitting. The entire installation shall meet manufacturers' recommendations.

## 3.3 CONDUIT INSTALLATION SCHEDULE

A. Conduit other than that specified below for specific applications shall not be used.

B. Underground Installations Within Five Feet of Foundation Wall: Rigid steel conduit.

C. Underground Installations More than Five Feet From Foundation Wall: Schedule 40 PVC conduit.

D. Directional Boring: HDPE conduit.

E. Under Slab on Grade Installations: Schedule 40 PVC conduit.

F. Exposed Outdoor Locations: Rigid steel conduit where subject to damage. Electrical metallic tubing with raintight fittings.

G. Concealed in Concrete and Block Walls: Electrical metallic tubing. Schedule 40 PVC conduit.

H. Within Concrete Slab: Schedule 40 PVC conduit.

I. Wet Interior Locations: Rigid steel conduit. Electrical metallic tubing with raintight fittings.

J. Concealed Dry Interior Locations: Electrical metallic tubing.

K. Exposed Dry Interior Locations: Electrical metallic tubing.

L. Motor and equipment connections: Flexible PVC coated metal conduit (all locations). Minimum length shall be one foot, maximum length shall be three feet. Conduit must be installed perpendicular to direction of equipment vibration to allow conduit to freely flex.

M. Light fixtures: Direct box or conduit connection for surface mounted and recessed fixtures. Flexible metal conduit from a J-box for recessed lay-in light fixtures. Conduit size shall be 3/8" minimum diameter and six (6) foot maximum length. Conduit length shall allow movement of fixture for maintenance purposes.

## 3.4 AUXILIARY GUTTERS (WIREWAYS) INSTALLATION

A. Bolt auxiliary gutter to wall using two (2)-piece hangers or steel channels fastened to the wall or in self-supporting structure.

B. Gasket each joint in oil-tight gutter.

C. Maintain grounding continuity between raceway components to provide a continuous grounding path under provisions of Section 260526.

## 3.5 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

B. Electrical box locations shown on Contract Drawings are approximate unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

C. No outlet, junction, or pull boxes shall be located where it will be obstructed by other equipment, piping, lockers, benches, counters, etc.

D. Boxes shall not be fastened to the metal roof deck. Maintain a minimum six (6) inch separation from the roof deck to boxes.

E. It shall be the Contractor's responsibility to study drawings pertaining to other trades, to discuss location of outlets with workmen installing other piping and equipment and to fit all electrical outlets to job conditions.

F. In case of any question over the location of an outlet, the Contractor shall refer the matter to the Architect/Engineer and install outlet as instructed by the Architect/Engineer.

G. The proper location of each outlet is considered a part of this contract and no additional compensation will be paid to the Contractor for moving outlets which were improperly located.

H. Locate and install boxes to allow access to them. Where installation is inaccessible, coordinate locations and provide 18 inch by 24 inch access doors.

I. Locate and install to maintain headroom and to present a neat appearance.

J. Install boxes to preserve fire resistance rating of partitions and other elements, using approved materials and methods.

K. Install boxes to preserve room acoustic ratings using approved material and methods.

L. Boxes mounted in common walls of adjacent rooms shall be offset by at least one stud space to minimize sound transference between rooms. If space does not allow for offsetting of boxes for adjacent rooms by one stud cavity, sound dampening material such as sound batting shall be installed around and between boxes.

3.6 OUTLET BOX INSTALLATION

A. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning to allow for surface finish thickness. The front edge of the box, plaster ring, extension ring, or listed extender shall not be set back of the finished wall surface more than ¼" in accordance with NEC 314.20. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

B. Do not install boxes back-to-back in walls. Provide minimum 6 inch separation, except provide minimum 24 inch separation in acoustic-rated walls.

C. Power
   1. Recessed (1/4" maximum) outlet boxes in masonry, concrete or tile construction shall be minimum 4-inch square, with device rings. Device covers shall be square-cut except rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted. Coordinate masonry cutting to achieve neat openings for boxes.

D. Low Voltage
   1. Recessed (1/4" maximum) outlet boxes in masonry, concrete or tile construction shall be minimum 4-11/16" square, 2-1/8" deep. Device covers shall be square-cut except rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted. Coordinate masonry cutting to achieve neat openings for boxes.

E. Provide knockout closures for unused openings.

F. Support boxes independently of conduit except for cast boxes that are connected to two (2) rigid metal conduits, both supported within twelve (12) inches of box.

G. Use multiple-gang boxes where more than one device are mounted together; do not use sectional boxes. Provide non-metallic barriers to separate wiring of different voltage systems.

H. Install boxes in walls without damaging wall insulation.

I. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

J. Ceiling outlets shall be four (4) inch square, minimum 2-1/8 inch deep except that concrete boxes and plates will be approved where applicable. Position outlets to locate luminaires as shown on reflected ceiling plans.

K. In inaccessible ceiling areas, position outlets and junction boxes within 6 inches of recessed luminaire, to be accessible through luminaire ceiling opening.

L. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

M. Provide cast ferroalloy or aluminum outlet boxes in exterior and wet locations.

N. Surface wall outlets shall be four (4) inch square with raised covers for one (1) and two (2) gang requirements. For three (3) gang or larger requirements, use gang boxes with non-overlapping covers.

## 3.7 FLOOR BOX INSTALLATION

A. Set boxes level and flush with finish flooring material and parallel to the walls of the room.

## 3.8 PULL AND JUNCTION BOX INSTALLATION

A. Locate pull boxes and junction boxes above accessible ceilings, in unfinished areas or furnish and install access panels in non-accessible ceilings where boxes are installed. All boxes are to be readily-accessible.

B. Support pull and junction boxes independent of conduit.

**END OF SECTION**

**SECTION 260553**

**IDENTIFICATION**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the labeling of power, lighting, general wiring, signal, fire alarm, and cabling.

1.2 REFERENCES

A. Applicable provisions of Division 1 shall govern work under this section.

B. Section 260519 – Low Voltage Electrical Power Conductors and Cables

C. Section 260523 – Control Cables

D. Section 271010 – Telecommunication Cabling Systems

1.3 SUBMITTALS

A. Include schedule for nameplates and stenciling.

B. Prior to installation, the Contractor shall provide samples of all label types planned for the project. These samples shall include examples of the lettering and material to be used. Samples shall be mounted on 8 1/2" x 11" sheets annotated, explaining their purposed use.
   1. Mail samples to:
      a. 5518 NW 88th Street, Des Moines Iowa, 50131 (Attention: Ryan Buhr)

PART 2 - PRODUCTS

2.1 MATERIALS

A. Labels: All labels shall be permanent, and machine generated. NO HANDWRITTEN OR NON-PERMANENT LABELS ARE ALLOWED. Exception: Back side of device plates and junction boxes may use handwritten, legible labeling on box covers, unless specifically prohibited by other specification sections.

B. Cable label size shall be appropriate for the conductor or cable size(s), outlet faceplate layout and patch panel design. All labels shall be self-laminating, white/transparent vinyl and be wrapped around the cable or sheath. Labels for power conductors (600V and lower) shall be cloth-type. Flag type labels are not allowed. The labels shall be of adequate size to

accommodate the circumference of the cable being labeled and properly self-laminate over the full extent of the printed area of the label.

C. Nameplates: Engraved three-layer laminated plastic, white letters on a black background.

D. Tape (phase identification only): Scotch #35 tape in appropriate colors for system voltage and phase.

E. Adhesive type labels not permitted except for phase and wire identification. Machine generated adhesive labels shall be permitted for device plates, 4-11/16" and smaller junction boxes, fire alarm and control devices.

## PART 3 - EXECUTION

### 3.1 GENERAL

A. Where mixed voltages are used in one building (e.g. 480 volt, 208 volt) each switch, switchboard, junction box, equipment, etc., on each system must be labeled for voltage in addition to other requirements listed herein.

B. All branch circuit and power panels must be identified with the same symbol used in circuit directory in main distribution center.

C. Clean all surfaces before attaching labels with the label manufacturer's recommended cleaning agent.

D. Install all labels firmly as recommended by the label manufacturer.

E. Labels shall be installed plumb and neatly on all equipment.

F. Install nameplates parallel to equipment lines.

G. Secure nameplates to equipment fronts using screws, rivets or manufacturer approved adhesive or cement.

H. Embossed tape will not be permitted for any application.

### 3.2 JUNCTION AND PULLBOX IDENTIFICATION

A. The following junction and pullboxes shall be identified utilizing spray painted covers:

| **System** | **Color(s)** |
|---|---|
| Secondary Power – 480Y/277V | Brown |
| Secondary Power – 208Y/120V, 240/120V | White |
| Emergency Power – 480Y/277V | Brown/Red |

| | |
|---|---|
| Emergency Power – 208Y/120V | White/Red |
| Fire Alarm | Red |
| Temperature Control | Green |
| Door Control and Door Monitoring System | Orange |
| Sound and Intercom Systems | Blue |
| Video Surveillance System/MATV | Yellow |

B. Provide circuit numbers, and source panel designations for power wiring. Other system shall be identified as shown on details or approved shop drawings. Temperature control shall identify the source.

## 3.3 POWER AND CONTROL WIRE IDENTIFICATION

A. Provide wire markers on each conductor in panelboard gutters, pull boxes, outlet and junction boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits, and with control wire number as indicated on schematic and interconnection diagrams or equipment manufacturer's shop drawings for control wiring.

B. All wiring shall be labeled within 2 to 4 inches of terminations. Each end of a wire or cable shall be labeled as soon as it is terminated including wiring used for temporary purposes.

## 3.4 WIRING DEVICE IDENTIFICATION

A. Wall switches, line voltage wall dimmers, motor switches, receptacles (interior, exterior, floor boxes, etc.), photocells and time clocks shall be identified with circuit numbers and source. Labeling shall be permanent and machine generated. Label shall have 1/4” black text on a clear label. Label shall be installed at consistent location on the face of the device cover plate.

## 3.5 NAMEPLATE ENGRAVING

A. Provide nameplates of minimum letter height as scheduled below.

B. Panelboards, Switchboards and Motor Control Centers: 1 inch; identify equipment designation. 1/2 inch; identify voltage rating, source and room location of the source.

C. Equipment Enclosures: 1 inch; identify equipment designation. 1/2 inch; identify voltage rating, source and room location of the source where applicable.

D. Circuit Breakers, Switches, and Motor Starters/VFD’s in Panelboards or Switchboards or Motor Control Centers: 1/2 inch; identify circuit and load served, including location.

E. Individual Circuit Breakers, Disconnect Switches, Enclosed Switches, Motor Starters, and VFD’s: 1/2 inch; identify source and load served.

F. Transformers: 1 inch; identify equipment designation. 1/2 inch; identify primary and secondary voltages, primary source, and secondary load and location.

G. Junction boxes: 1 inch; identify system source(s) and load(s) served. Junction boxes may be neatly identified using a permanent marker.

## 3.6 PANELBOARD DIRECTORIES

A. Typed directories for panels must be covered with clear plastic, have a metal frame. Room number on directories shall be Owner's numbers, not Plan numbers unless Owner so specifies.

## 3.7 ARC FLASH LABELS

A. Install ARC FLASH WARNING signs on all switchboards, panelboards, and motor control centers.

## 3.8 FIRE ALARM DEVICES

A. Install computer printed labels on all addressable fire alarm devices indicating the device loop and address. Label shall have 1/4" black text on a clear label.
   1. Coordinate label location on devices with the Owner prior to installation.

**END OF SECTION**

**SECTION 260943**

**DIGITAL LIGHTING CONTROLS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all work required to provide and install the lighting control components, conductors, cabling and raceways to form a distributed-type digital lighting control system. The lighting control system shall provide time-based, sensor-based (occupancy and/or daylight) and manual lighting controls, as indicated on plans and schedules.

B. Section includes:
   1. Zone controllers
   2. Plug load controllers
   3. Manual controls
   4. Digital occupancy sensors
   5. Digital photo sensors
   6. System relay panel
   7. Network components
   8. Programming tools
   9. Accessories
   10. Wiring

1.2 REFERENCES

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

B. Specification 260923 Lighting Control Devices

C. Specification 260519 Low-Voltage Electrical Power Conductors and Cables

D. Specification 260523 Control Cables

E. Specification 262728 Wiring Devices

F. Refer to Digital Lighting Control Narrative and Switch Schedule on plans.

1.3 SUBMITTALS

A. Product data: Provide a detailed cut sheet with model number(s) and included options clearly noted for each system component type, except cabling. Indicate dimensions.

B. Shop drawings:
   1. CAD drawings:
      a. Selected manufacturer shall request CAD floor plans from the Engineer and layout all system devices on the CAD plan, except for cabling. A legend shall be provided on the CAD plan to aid in quick identification of each device and function of that device.
      b. For occupancy and photo sensors: Selected manufacturer shall review ceiling heights, room obstructions (e.g. ceiling fans) and room finishes shown on the architectural plans. Where a conflict arises between the design on plan and selected manufacturer's recommendations, the manufacturer's recommendation shall dictate the type and quantity of devices used in that space.
      c. The locations and quantities of occupancy and photo sensors shown on the drawings are diagrammatic and indicate only the rooms which are to be provided with those sensors. The Contractor shall include in their bid the additional occupancy sensors needed to properly and completely cover the respective room.
   2. One-line block diagram: Project specific with nomenclature matching plans. Show interconnections between components specified in this section and necessary system interfaces. Indicate required communication cabling types.
   3. Wiring diagrams: Power, signal, and control wiring. Coordinate nomenclature with block diagram.
   4. Custom button labels: Submit a custom button label form for each manual switch requiring custom labels.

C. Warranties: Submit sample warranty letter meeting requirements specified in this section.

## 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit under requirement and format listed in Specification 260500 Common Work Results

B. Include the following additional documentation:
   1. Copy of on-site system startup reports.
   2. All required submittals for this section, updated to reflect required changes from review comments.
   3. System device addresses and programmed settings (e.g. an occupancy sensor time delay).
   4. Mark locations of zone controllers and interfaces on the as-built drawings.
   5. Warranty letter(s) indicating dates of coverage and warranty claim contact information.

## 1.5 QUALITY ASSURANCE

A. Source Limitations: Digital lighting control system components shall be sourced from a single manufacturer.
   1. Exception: Occupancy sensors and emergency relay devices, tested with and approved by the manufacturer of the selected digital lighting control system, may be from different manufacturer. However, all occupancy sensors (digital and analog) must be from the same 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.

## 1.6 DEFINITIONS

A. BAS: Building automation system.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.

C. RS-232: A serial network protocol complying with TIA/EIA-232.

## 1.7 PLAN NOTATION

A. Luminaire zoning notation on plans:
   1. Basic room zoning
      a. Rooms with Control Devices but without luminaire subscripts indicates that room contains either one zone of dimmed control or two or fewer zones of switched control. The luminaire subscripts have been omitted to maintain drawing clarity.
   2. Complex room zoning
      a. To better define zoning intent in areas containing two or more dimmed lighting zones or three or more switched lighting zones, luminaire subscripts (e.g. ‘a1’, ‘a2’, etc) have been shown next to each luminaire on plan.
      b. Luminaires with matching subscripts shall be controlled together as one lighting control zone. A luminaire with two subscripts (e.g. ‘a1,a2’) indicates that luminaire belongs to two independent lighting control zones to allow for multi-level or step-dimming control.

B. Digital occupancy sensors
   1. Digital occupancy sensors intended to be part of the digital lighting control system will have a subscript on plan.
   2. Basic rooms: All the luminaires in the room shall be controlled by the occupancy sensor(s) shown in that room. Subscripts indicating zones controlled have been omitted from the occupancy sensor.
   3. Complex rooms: Subscripts of lighting zones controlled by each occupancy sensor will be indicated on plan below the occupancy sensor symbol (e.g. ‘a,b’).

C. Digital photo sensors
   1. When a photosensor is indicated within a space, a dashed line shall identify the luminaires controlled (switched or dimmed) by that photosensor as a common control group.
   2. If no control zone subscripts are shown, all luminaires within the daylight zone shall be controlled as a single group.
   3. Where control zone subscripts are shown, the subscript designation shall correspond to the luminaire subscript and shall identify the specific fixtures controlled by the associated photosensor.

D. System relay panel Luminaire subscripts will reflect the name assigned to the relay panel. A relay panel schedule on the plans will indicate loads controlled.

1.8 COORDINATION

A. Verify required BAS interface type with mechanical controls contractor. Coordinate audio/video interfaces with audio/video systems contractor.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site. Store and protect under provisions of Specification 260500 General Work Results.

1.10 WARRANTY

A. All equipment shall be warranted to be free of defects in materials and workmanship by the manufacturer for the period of five (5) years from the date of successful system startup.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Refer to Lighting Control Narrative on plan.

2.3 PLUG LOAD CONTROLLER

A. A 20amp, 120 volt rated relay in plenum rated enclosure suitable for mounting to a junction box.

B. Provides switched control of one (1) 120 volt receptacle circuit by utilizing input from the digital occupancy sensor serving the room.

C. Refer to Receptacle Schedule for symbol, description and manufacturer/model number of controlled receptacles.

D. The plug load controllers ARE NOT shown plans. Selected manufacturer of this Section shall provide in quantities as needed to meet requirements shown on plans.

2.4 MANUAL CONTROLS

A. Low voltage manual switches

1. Field-programmable, momentary-contact, plastic push buttons with LED light for each button indicating status. Provide remote interface and remote power supply, if necessary, for proper switch operation.
2. Multiple switches shall be ganged together, if needed, to provide control indicated on plans at each manual control location.
3. For single lighting zone room switches, standard "ON", "OFF", "RAISE" or "▲", and "LOWER" or "▼" labels are acceptable. Custom button labels are not required.
4. For multi-lighting zone room switches, provide custom button labels as indicated on Digital Lighting Control System – Switch Schedule on plan.
5. Device color shall be white with cover plate to match Specification 262726 Wiring Devices

B. Handheld remote
1. Handheld remote with field-programmable buttons and infrared transceiver for manual control of lighting zones within a room. Battery powered.

## 2.5 DIGITAL OCCUPANCY SENSORS

A. Device shall be designed for use with the digital lighting control system.

B. Sensors to be low voltage devices and shall be powered from a zone controller.

C. Provide with field-programmable time delay.

D. Provide with an LED as a visual means that motion is being detected during both testing and normal operation.

E. Provide mounting hardware suitable for specified mounting location.

F. Refer to Digital Lighting Controls – Switch Schedule and floor plans for additional information.

## 2.6 DIGITAL PHOTO SENSORS

A. Interior photo sensor: Ceiling mounted digital sensor that provides light level readings directly to the zone controller for automatic daylight harvesting. Powered by and connected to the zone controller.

B. Exterior photocell: Analog photo sensing device specifically designed for exterior use and connected to the system via a suitable interface module. Photocell to have weatherproof housing with visor for shading and lens protection. Adjustable light level sensitivity.

## 2.7 SYSTEM RELAY PANEL

A. Provides centralized, switched control of exterior lighting loads or lighting loads in areas where distributed zone controllers are not practical (e.g. large vaulted-ceiling lobby, site lighting). Panel shall be feed-through type (i.e. no integral overcurrent protection).

B. Panel enclosure:
   1. Steel NEMA 1, IP-20 rated enclosure with removable, lockable door and suitable for mounting type noted on plans (i.e. flush or surface).
   2. If the relay panel size indicated on the schedule is not a standard size for the selected manufacturer, the next largest standard relay panel size shall be provided.
   3. The entire enclosure shall be painted with the manufacturer's standard finish color.

C. Relays:
   1. Heavy-duty, mechanically latching type, minimum 20 amp continuous rated contacts with ON/OFF LED indicator lights on each relay.
   2. Suitable for the type and voltage of loads served and rated for at least 50,000 cycles at rated capacity.
   3. Provide relay quantities per Digital Lighting Controls – Relay Panel Schedule on plan.

D. Control module: Programming of individual relays or groups of relays based various low voltage inputs via interfaces, time clock and/or astronomical time clock via digital lighting control network. Provide network bridge interface card in panel. Relays may be assigned to multiple control groups.

## 2.8 NETWORK COMPONENTS

A. Network Bridges
   1. Allows a zone controller and stand-alone system components to become part of a building-wide lighting control network. Converts communication via universal protocol (e.g. BACnet MS/TP) to system-specific protocol.
   2. Provide network bridges to connect all digital lighting control system devices to form a networked digital lighting control system.
   3. Network bridges ARE NOT shown on plans. Provide in quantities as needed.

B. Network segment manager:
   1. Connects network bridges on the project to form a segment network. Allows for time-of-day and astronomical time clock scheduling of zones, plus monitoring and programming of all devices, including but not limited to digital occupancy sensors, digital daylight sensors and manual wall stations using any computer with internet access and a compatible web browser.
   2. Contains a web-browser user interface and connects to building network. Supports third party integration with BAS via BACnet IP.
   3. Network segment managers ARE NOT shown on plans.

C. Wireless network bridge: Allows for remote network lighting system components to be integrated into the overall lighting network (e.g. free-standing out-building). At a minimum, one wireless bridge is required in both the main building and the remote building. Network bridges ARE NOT shown on plans. All buildings shall be interconnected into the lighting control network.

D. Network devices above ARE NOT shown on plan. Provide components listed above in quantities as needed for a complete and functioning system.

2.9 PROGRAMMING TOOLS

A. Web-based programming: Provides connection via any internet-connected computer with username/password protection. Allows for multiple users at one time. No local software or user licenses required on the user's computer. Connects to user's local area network (LAN) or via the BAS (BACnet MS/TP protocol). GUI on website allows for programming and monitoring of all networked digital lighting control system components. Requires data connection to LAN with Ethernet static IP address, plus 120 volt receptacle.

B. Programming tool IS NOT shown on plans. Furnish programming tool above for system programming.

2.10 ACCESSORIES

A. RS-232 interface: Serial device that allows for control of the digital lighting system by a third-party control system (e.g. A/V system) and integration of motorized shades. Built-in protocol allows for automatic response to message requests from third party devices. RS-232 interfaces ARE shown on plans.

B. Digital I/O interface: Two (2) input and one (1) 24 VDC, 1 amp isolated SPDT relay with N.O. and N.C. output for integration with third-party devices, such as input from a BAS time clock or output to a piece of HVAC equipment via BAS (e.g. turn up HVAC equipment when occupancy sensor senses occupancy). Digital I/O interfaces ARE shown on plans. Isolated output relay: 24 VDC, 1 amp isolated SPDT relay with N.O. and N.C. output only for control of third-party HVAC equipment. Output relays ARE shown on plans.

C. Analog occupancy sensor interface: Allows for third-party and analog occupancy sensors to be connected into the digital lighting control system. Analog interfaces ARE NOT shown on plans.

2.11 WIRING

A. Line-voltage conductors: Comply with Specification 260519 Low-Voltage Electrical Power Conductors and Cables.

B. Digital lighting control system cables: Comply with selected digital lighting control manufacturer's recommendations. All low voltage communication cabling shall be plenum rated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Zone controllers

1. Rooms with accessible ceiling (e.g. lay-in grid): Install zone controller for each room above accessible ceiling directly above a manual control location. Mark location of zone controller on as-built drawing.
2. Rooms with open ceilings: Install zone controller in adjacent room with accessible ceiling. Mark location of zone controller on as-built drawing.
    a. Exception: Zone controllers for back-of-house rooms (e.g. storage room) with open ceilings may be installed exposed on wall near bottom of structure and above manual control location.
3. Rooms with inaccessible (e.g. gypsum) ceilings: Install zone controller in adjacent room with accessible ceiling or adjacent back-of-house room with open ceiling. Mark location of zone controller on as-built drawing.
4. Connect a network bridge to each zone controller, per manufacturer's recommendation, allowing all the downstream devices (e.g. occupancy sensors, photo sensors, manual controls) to become network devices. Install the network bridge adjacent to each zone controller. Connect all network bridges, per manufacturer's recommendations, to form a complete digital lighting control network.

B. Manual Controls
1. Install low voltage wall stations at locations shown on plans. All cabling shall be per manufacturer's recommendation. Connect to zone controller.
2. Program each button function per Digital Lighting Control System – Switch Schedule on plans.
3. Install custom button labels for $\$_{LV}$ wall stations and suitable cover plates for all manual controls.

C. Digital Occupancy Sensors
1. Connect to zone controller per manufacturer's recommendation.
2. It shall be the contractor's responsibility to locate and aim sensors in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations. Rooms shall have 90% - 100% coverage (minor motion in office environments).
3. Ceiling sensors shall not be installed within four (4) feet of HVAC air diffusers or heating blowers.
4. Provide a minimum 6' service loop in the cable at the ceiling sensor location to allow for sensor relocation if necessary.

D. Digital Photo Sensors
1. Install the photo sensor at the location recommended by the manufacturer and connect to the system per manufacturer's recommendations utilizing any necessary interface.
2. Daylight harvesting shall begin only after the target foot-candle level(s) in the room has been reached. Light levels for initiating daylight harvesting of each zone shall be field programmed by the factory authorized representative during the start-up process.
3. Aim exterior photo cell north.

E. System Relay Panels
1. Install relay panel at location shown on plan. Route circuits through panel to luminaires served based on Digital Lighting Controls – Relay Panel Schedule on plan.
2. Provide relay panel network bridge interface to digital lighting system

F. Network components
   1. Install a network bridge near the zone controllers for all zones.
   2. Install network segment manager(s) on a wall in MDF or IDF closet. Connect to dedicated, spare 20 amp, 1-pole circuit breaker in nearest 208/120 volt branch panel. Provide one (1) building network data drop to each segment manager meeting requirements of Specification 271500 Communications Horizontal Cabling. Coordinate internet access/IP address with owner's IT staff.
   3. Install network switches/routers in owner's IT rack in MDF or IDF closet(s). Coordinate acceptable locations with owner's IT staff.
   4. Install wireless network bridge device in main building and out-building per manufacturers requirements.

G. Accessories
   1. RS-232 interface
      a. All lighting scene presets programmed by the factory-authorized technician of the digital lighting control system shall be made available to the A/V contractor for easy integration.

   2. Isolated output relay: Install device above accessible ceiling in rooms shown on plan. Wiring to device output and programming of third-party system (e.g. BAS system) by others.
   3. Infrared partition sensor: Install device at location shown on plans. Partition sensor interface shall be located above nearest accessible ceiling. Digital lighting control system shall automatically reconfigure manual and automatic lighting controls based on partition(s) position.
   4. Analog occupancy sensor interface: Install device above accessible ceiling in rooms with analog occupancy sensors. Quantity of interfaces needed determined by selected manufacturer based on lighting control requirements for the room.

## 3.2 WIRING INSTALLATION

A. Install all low voltage cabling in raceways except where installed above accessible ceilings.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions. Provide a physical barrier between

## 3.3 PRE-INSTALLATION MEETING

A. A factory-authorized technician from the selected system manufacturer shall meet with the electrical contractor on-site prior to installation of the system to step through the installation process, important installation requirements and answer contractor questions.

3.4 SYSTEM START-UP

A. Upon completion of the installation by the contractor, the installation of the devices shall be reviewed on-site by the manufacturer's factory authorized technician. This visit may be combined with the occupancy sensor startup and training visit. The owner shall be included in determining the initial programming of time sweeps and similar functions.

B. The Electrical Contractor shall provide both the manufacturer and the Electrical Engineer with 10 working days written notice of the scheduled start-up date.

C. Factory-authorized technician shall utilize their laptop computer, the system start-up USB flash drive and a system cable to connect to and program each system device per plans and owner input. At the end of programming, the USB flash drive shall be turned over the owner for future re-programming.

D. Factory-authorized technician shall setup the web-based software provided with the digital lighting control system to fit the project and then program each system device per plans and owner input.

3.5 OWNER TRAINING

A. After system start-up, the factory-authorized technician shall train the owner’s representatives in the system architecture, components, programming and any necessary maintenance for the system. This training may take place during the system start-up trip. Operations and maintenance manuals shall be delivered to the owner prior to the owner training being scheduled.

3.6 ADJUSTING

A. Eight (8) months of date of Substantial Completion, provide remote assistance in adjusting sensors and to assist Owner's personnel in making program changes to suit actual occupied conditions. Provide one meeting during normal occupancy hours for this purpose.

**END OF SECTION**

**SECTION 262200**

**LOW VOLTAGE TRANSFORMERS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the dry type general purpose two (2) winding transformers and dry type isolation transformers.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

B. NEMA ST-20 Dry-Type Transformer for General Applications

C. U.S. DOE 10 CFR Part 431

1.3 SUBMITTALS

A. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, loss data, efficiency at 25, 50, 75 and 100 percent rated load, sound level, tap configurations, insulation system type, and rated temperature rise.

1.4 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store and protect equipment in a dry location with uniform temperature. Cover ventilating openings to keep out dust.

B. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2 - PRODUCTS

2.1 DRY TYPE GENERAL PURPOSE TWO WINDING TRANSFORMERS

A. Dry Type General Purpose Transformers: Factory-assembled, air cooled, dry type general purpose two (2) winding transformers; ratings as shown on the Drawings.

B. Transformers shall meet the DOE 2016 energy efficiency standards.

C. Insulation Class: 220° C system.

D. Winding temperature rise shall be rated at 150° C above a 40° C ambient.

E. Case temperature shall not exceed 50° C rise above a 40° C ambient at its warmest point.

F. Winding Taps, Transformers 15 KVA and Larger (NEMA ST-20): Four (4) 2-1/2 percent taps, two (2) above and two (2) below rated voltage, full capacity taps on primary winding.

G. Sound Levels: Meet NEMA ST-20 standards.

H. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap sized to meet NEMA and UL standards.

I. Coil Conductors: Continuous windings with termination pads brazed or welded.

J. Isolate core and coil from enclosure using vibration absorbing mounts.

K. Enclosure: As Indicated on drawings. Provide lifting eyes or brackets.

L. Nameplate: Include transformer connection data.

M. Mounting: Transformers 75 KVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger that 75 KVA shall be suitable for floor or trapeze mounting.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Set transformer plumb and level.

B. Use flexible conduit, 2 ft. minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

C. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.

D. Provide sufficient space around transformer for cooling as recommended by the manufacturer.

3.2 FIELD QUALITY CONTROL

A. Check for damage and tight connections prior to energizing transformer.

B. Measure primary and secondary voltages and make appropriate tap adjustments within 2-1/2% of the normal operating load after the building is in full operation.

**END OF SECTION**

**SECTION 262413**

**SWITCHBOARDS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the main and/or distribution switchboard(s) indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this section

B. ANSI C57.13 Instrument Transformers

C. NEMA AB 1 Molded Case Circuit Breakers

D. NEMA KS 1 Enclosed Switches.

E. NEMA PB 2 Dead Front Distribution Switchboards.

F. NEMA PB 2.1 Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or Less.

G. UL-891 - Dead Front Switchboards.

1.3 SUBMITTALS

A. Include front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; one-line diagrams; size and number of bus bars per phase, neutral, and ground; switchboard instrument details; instructions for handling and installation of switchboard; and electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves and interrupting ratings of all equipment and components.

B. Submit the manufacturer provided coordination study and the overcurrent device set point recommendations to the Engineer for approval.

C. Accessories.

1.4 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

B. In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Bus tightening intervals and procedures.

2. Overcurrent protective device testing and maintenance procedures.

3. Coordination study and the overcurrent device set point recommendations.

4. Field report noting final adjustments to overcurrent protective device settings.

5. Ground-fault protection system performance testing reports per NEC 230.95.

## 1.5 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with NEMA PB2.1 and manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

# PART 2 - PRODUCTS

## 2.1 SWITCHBOARD CONSTRUCTION AND RATINGS

A. Type I: Switchboard shall be front accessible with the following features

1. Device mounting:
   a. Normal Power Switchboard:
      1) Main breaker: Individually mounted and compartmented or group mounted with feeder breakers.
      2) Feeder breakers: Group mounted.

2. Section alignment: As required for space allocated and feeder installation.

3. Accessibility:
   a. Main section line and load terminals: Front and side.
   b. Distribution section line and load terminals: Front.
   c. Through bus connections: Front and end.

4. Bolted line and load connections.

5. Full height wiring gutter covers for access to wiring terminals.

6. Short Circuit Current Rating: 50,000 amperes rms symmetrical, minimum, or as shown on the Drawings, whichever is higher.

B. Buses

1. The switchboard bussing (and all other current carrying parts such as fingers, neutral and ground buses) shall be plated copper. The bussing shall be of sufficient cross-sectional area to meet UL 891 temperature rise requirements. Brace the bus to withstand the available short circuit current at the particular location and as shown on the drawings. No magnetic material shall be used between buses to form a magnetic loop.

2. For 4-wire systems, the neutral bus shall be the equivalent ampacity as the phase bus bars. Provide neutral disconnect link to permit isolation of neutral bus from the common ground bus and service entrance conductors.

3. Provide a copper ground bus through the length of the switchboard sized per UL 891 and NFPA requirements.

4. Main Bonding Jumper: Where identified on the Drawings connect an uninsulated 1/4 inch by 2 inch copper bus between the neutral and ground buses to establish the system common ground point.

5. Where spaces are indicated for future breakers, extend bus bars, drill and tap bus, and fully equip for the future breakers, including all connectors and mounting hardware.

C. Enclosure

1. Factory-assembled, dead front, metal-enclosed, and self-supporting switchboard assembly conforming to NEMA PB2, and complete from incoming line terminals to load-side terminations.

2. All closure plates shall be screw removable and small enough for easy handling by one person.

3. Finish: Manufacturer's standard medium gray enamel over external surfaces. Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.

4. Enclosure shall be NEMA PB 2 Type 3R - Raintight.

D. Control Wiring: Control wiring shall be 600 volt class B stranded SIS. Install all control wiring complete at the factory adequately bundled and protected. Wiring across hinges and between shipping units shall be Class C stranded. Size in accordance with NEC. Provide control circuit fuses.

E. Provide metering transformer compartment for Utility Company's use. Compartment size, location, bus spacing and drilling, door, and locking and sealing requirements shall meet the requirements of the local utility company. Provide metering equipment to accommodate a minimum of six (6) Utility Company meters.

F. Metering

1. Refer to specification section 262713, Electricity Metering.

G. Ground Fault Protection of Equipment: Provide GFPE on breakers 1000A and greater where system voltage to ground is greater than 150V.

1. Service disconnects

2. Feeder disconnects

3. Branch circuit disconnects

## 2.2 MAIN OVERCURRENT PROTECTIVE DEVICES

A. Type I Switchboard: Provide UL Listed and Labeled molded case circuit breakers in accordance with NEC and as shown on the drawings. Circuit breakers shall be the solid state adjustable trip type.

1. Trip units shall be available with the following field adjustable tripping characteristics:

a. Ampere setting (continuous)
b. Long time band
c. Short time trip point
d. Short time delay
e. Instantaneous trip point
f. Ground fault trip point
g. Ground fault trip delay

2. Trip configuration and settings shall be as indicated on the Drawings. Final settings shall be as shown on the electrical system protective device study.

3. Maintenance mode switched trip units: The main breaker trip unit shall utilize Arc Flash Reduction Maintenance System (ARMS) to reduce the instantaneous pickup value when activated. The ARMS shall provide a clearing time of 0.04 seconds with a minimum of settings from 2.5X to 10X of the sensor value. The ARMS shall be enabled by a switch on the trip unit with blue indicator LED. A remote communication link shall also be provided for enable/disable and confirmation.

4. Breakers, which have same rating, shall be interchangeable with each other.

## 2.3 FEEDER OVERCURRENT PROTECTIVE DEVICES

A. Provide UL listed and labeled molded case circuit breakers, in accordance with the NEC, as shown on the drawings, and as herein specified.

B. Non-adjustable Trip Molded Case Circuit Breakers:

1. Molded case circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for 100 ampere frame size or less. Magnetic trip shall be adjustable from 3X to 10X for breakers with 600 ampere frame size and higher. Factory setting shall be LOW unless otherwise noted.

2. Breaker features shall be as follows:

   a. Quick-make, quick-break, operating mechanisms.
   b. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
   c. Electrically and mechanically trip free.
   d. An operating handle which indicates ON, TRIPPED and OFF positions.
   e. Line and load connections shall be bolted.
   f. Interrupting rating shall not be less than the maximum short circuit current available at the line.
   g. An overload on one pole of a multipole breaker shall automatically cause all the poles of the breaker to open.

C. Adjustable Trip Molded Case Circuit Breakers:

1. Provide molded case, solid state adjustable trip type circuit breakers.

2. Trip units shall be available with the following field adjustable tripping characteristics:

   a. Ampere setting (continuous)
   b. Long time band
   c. Short time trip point
   d. Short time delay
   e. Instantaneous trip point
   f. Ground fault trip point
   g. Ground fault trip delay

3. Trip configuration and settings shall be as indicated on the Drawings. Final settings shall be as shown on the electrical system protective device study.

4. Breakers, which have same rating, shall be interchangeable with each other.

## 2.4 ACCESSORIES

A. Key interlock arrangement where indicated on the Drawings, which requires one main circuit breaker in a double-ended unit substation to be open before the tie circuit breaker can be closed.

B. Provisions for padlocking in the OPEN position.

## 2.5 COORDINATION OF OVERCURRENT PROTECTIVE DEVICES

A. The manufacturer shall perform a coordination study of the electrical system and recommend set points for all of the overcurrent and ground fault trip adjustments on the equipment

provided. The coordination study and set point recommendations shall be submitted to the Engineer for approval.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install switchboard in locations shown on Drawings, in accordance with manufacturer's written instructions and NEMA PB 2.1.

B. All installation shall be in accordance with manufacturer’s published recommendations.

C. Anchor switchboard to the slab with plated 1/2 inch minimum anchor bolts, or as recommended by the manufacturer.

D. Exterior Location. Mount switchboard on concrete slab. Unless otherwise indicated, the slab shall be at least 8 inches [200mm] thick, reinforced with a 6 by 6 inch No. 6 mesh placed uniformly 4 inches from the top of the slab. Slab shall be placed on a 6 inch thick, well-compacted gravel base. The top of the concrete slab shall be approximately 4 inches above the finished grade. Edges above grade shall have 1/2 inch chamfer. The slab shall be of adequate size to project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. Concrete work shall be as specified in section 033000, Cast-in-Place Concrete.

E. Interior Location. Mount switchboard on concrete slab. Unless otherwise indicated, the slab shall be at least 3-1/2 inches thick. The top of the concrete slab shall be approximately 3-1/2 inches above finished floor. Edges above floor shall have 1/2 inch chamfer. The slab shall be of adequate size to project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. Concrete work shall be as specified in section 033000, Cast-In-Place Concrete.

F. Field Connections: Make field connections of buses between switchboard sections (rigid connection) and to transformers (flexible metal conduit) with splice bus and hardware provided by the switchboard manufacturer.

G. Equipment Settings: Properly set adjustable current and voltage settings as noted on protective device and relay coordination submittals.

H. Tighten accessible bus connections and mechanical fasteners after placing switchboard.

I. Restore all damaged surfaces to factory finish.

J. Inspection:

1. Thoroughly inspect the switchboard for items such as loose connections and presence of foreign materials and remedy prior to energizing the switchboard.

2. All bolted connections shall be torqued to the manufacturer's recommendations.

K. Double lugging on one protected device to feed two (2) separate loads will not be permitted.

L. Provide ARC flash identification per NFPA 70E.

3.2 FIELD QUALITY CONTROL

A. Acceptance Checks and Test

1. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections and electrical tests:

a. Visual and Mechanical Inspection:
1) Compare equipment nameplate data with specifications and approved shop drawings.
2) Inspect physical, electrical, and mechanical condition.
3) Confirm correct application of manufacturer's recommended lubricants.
4) Verify appropriate anchorage, required area clearances, and correct alignment.
5) Verify that circuit breaker sizes and types correspond to approved shop drawings.
6) Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energizing. Tightness shall be in accordance with manufacturer's recommended values.
7) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
8) Clean switchboard.
9) Inspect insulators for evidence of physical damage or contaminated surfaces.
10) Verify correct shutter installation and operation.
11) Exercise all active components.
12) Verify the correct operation of all sensing devices, alarms, and indicating devices.
13) If applicable, verify that vents are clear.
14) If applicable, inspect control power transformers.

b. Electrical Tests:
1) Perform insulation-resistance tests on each bus section. Test voltage shall be 1000 volts, and minimum acceptable value for insulation resistance is 2 megohms.
2) Perform overpotential tests.
3) Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.

3.3 ADJUSTING

A. Adjust all operating mechanisms for free mechanical movement.

B. Adjust trip and time delay settings to values as recommended in coordination study provided by manufacturer or as instructed by the A/E. Include a copy of the coordination study and recommended circuit breaker set points in the O&M manual.

END OF SECTION 262413

**SECTION 262416**

**PANELBOARDS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the main, distribution and branch circuit panelboards indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

1.3 SUBMITTALS

A. Include outline and support point dimensions, voltage, main bus ampacity, and integrated short circuit ampere rating.

B. Circuit breaker enumeration (frame, ATE, poles, I.C.): Indicate if circuit breakers are suitable for the panelboards' Fully Rated Equipment Rating, or where acceptable, are series connected devices that have been test verified and listed with UL (include documentation proving the compatibility of the proposed circuit breaker combinations). Circuit breakers do not have to be listed as series connected devices when all of the circuit breaker interrupting ratings are equal to, or greater than, the short circuit rating of the panelboard.

C. When indicated on the panelboard schedule, a coordinated selective scheme between the main circuit breaker and branch/feeder circuit breakers so that under fault conditions the branch/feeder circuit breaker clears the fault while the main circuit breaker remains closed.

D. Accessories.

1.4 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver panelboards in factory-fabricated water-resistant wrapping..

B. Handle panelboards carefully to avoid damage to material components, enclosure and finish.

C. Store in a clean, dry space and protected from the weather.

1.6 EXTRA MATERIALS

A. Keys: Furnish two (2) keys for each panelboard to Owner.

PART 2 - PRODUCTS

2.1 MAIN AND DISTRIBUTION PANELBOARDS

A. Panelboards: Circuit breaker type.

B. UL label “SUITABLE FOR USE AS SERVICE EQUIPMENT” where used as service equipment.

C. Enclosure: NEMA Type as indicated on the drawings. Minimum cabinet size: 5-3/4 inches deep; 20 inches wide, with 5" minimum gutter space top and bottom. Constructed of galvanized code gauge steel.

D. Provide cabinet front with hinged door with flush lock. Front cover shall be hinged to allow access to wiring gutters without removal of panel trim. Hinged trim shall be held in place with screw fasteners. Finish in manufacturer's standard gray enamel.

E. Provide metal directory holders with clear plastic covers.

F. Provide panelboards with copper bus (phase buses, bus fingers, etc.), ratings as scheduled on Drawings. Provide ground bars in all panelboards. Neutral and ground bars can be dual rated ALCU9. All spaces shall have bus fully extended and drilled for the future installation of breakers.

G. Circuit breakers shall be 125 VDC/240 AC rated for nominal 208Y/120V panels and 480Y/277V rated for nominal 480Y/277V panels. Minimum interrupting ratings shall be 10,000 amperes for 120/208V circuits and 14,000 amperes for 277/480V circuits, unless higher rating noted on the Contract Documents.

H. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Provide circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits. Breakers 225 ampere through 400 ampere shall have continuously adjustable magnetic pick-ups of approximately five to ten times trip rating.

I. Electronic Trip Circuit Breakers: Where indicated on the Drawings, provide circuit breakers with electronic trip unit. Adjustable settings may include long-time, short-time, instantaneous, and ground fault pick-up and delay.

J. Circuit breakers shall be bolt-on type with common trip handle for all poles. No handle ties of any sort will be approved.

K. Shunt trip breakers shall be provided where indicated.

L. Ground fault breakers shall be provided where indicated.

2.2 BRANCH CIRCUIT PANELBOARDS

A. Lighting and Appliance Branch Circuit Panelboards: Circuit breaker type.

B. UL label “SUITABLE FOR USE AS SERVICE EQUIPMENT” where used as service equipment.

C. Enclosure: Type as indicated on the drawings. Minimum cabinet size: 5-3/4 inches deep; 20 inches wide with 5" minimum gutter space top and bottom. Constructed of galvanized code gauge steel.

D. Provide surface cabinet fronts with concealed trim clamps, concealed hinge and flush cylinder lock all keyed alike. Front cover shall be hinged to allow access to wiring gutters without removal of panel trim. Hinged trim shall be held in place with screw fasteners. Finish in manufacturer's standard gray enamel.

E. Provide flush cabinet fronts with concealed trim clamps, concealed hinge and flush cylinder lock all keyed alike. Finish in manufacturer's standard gray enamel.

F. Provide metal directory holders with clear plastic covers.

G. Provide panelboards with copper bus (phase buses, bus fingers, etc.), ratings as scheduled on Drawings. Provide ground bars in all panelboards. Neutral and ground bars can be dual rated ALCU9. All spaces shall have bus fully extended and drilled for the future installation of breakers.

H. Minimum System (i.e. individual component) Short Circuit Rating: As shown on the Drawings.

I. Molded Case Circuit Breakers: Bolt-on type thermal magnetic trip circuit breakers. Provide UL Class A ground fault interrupter circuit breakers where shown on Drawings. Provide circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits. Breakers 225 ampere through 400 ampere shall have continuously adjustable magnetic pick-ups of approximately five to ten times trip rating.

J. Do not use tandem circuit breakers.

K. Circuit breakers shall be bolt-on type with common trip handle for all poles. No handle ties of any sort will be approved.

L. Shunt trip breakers shall be provided where indicated.

M. Ground fault breakers shall be provided where indicated.

N. All of the panelboards provided under this section shall be by the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See specification section 260529 Hangers and Supports.

B. Install panelboards plumb with wall finishes.

C. Height: 6 ft to top.

D. On surface mounted panels, install a 6” by 6” wireway the width of the panel tub 6” above the top of the panel, parallel to the tub. Install end caps on the wireway. Install four (4) 2” conduits, with bushings, between the panel tub and the wireway. Homerun conduits shall be terminated at the wireway. Wireway shall have a cover with screw fasteners. The wireway aids in the installation of new branch circuits to the existing panel by allowing new conduit to be installed at the wireway, instead of the panel, where there is no exposed live parts.

E. Install a crimp type stud termination to stranded conductor when terminating on circuit breakers without a captive assembly rated for terminating stranded conductors.

F. Provide filler plates for unused spaces in panelboards.

G. See specification section 260553 Identification. Provide typed circuit directory for each branch circuit panelboard. Circuit labels shall indicate actual loads served. Use final room numbers and names of equipment. Do not use panel directories used for construction purposes. Revise directory to reflect circuiting changes required to balance phase loads.

H. Provide ARC flash identification per NFPA 70E.

I. Stub five (6) empty 1” conduits to accessible location above ceiling or below floor out of each recessed panelboard. Cap these conduits to prevent material from entering them.

J. Keep panel interior clean at all times.

K. Cabinet exteriors shall be maintained free of mud, spray-on insulation, paint spray and all substances not placed on the exterior surface by the panelboard manufacturer.

L. For panelboards located in areas accessible to the public, paint the exposed surfaces of the trims, doors, and boxes with finishes to match surrounding surfaces after the panelboards have been installed.

M. Panel cabinets shall not be used as raceways or pull boxes for adjacent equipment. Panel cabinets shall not contain wire splices. Panel wiring shall be installed in a neat and workmanlike manner with wire conforming to the contours of the cabinet. Wire bundles shall be wire tied and installed in a manner to protect wire insulation from cover screws and other sharp edges. All phase conductors shall be labeled with a circuit number, readily visible to the panelboard front without removing the dead front cover. All neutral conductors shall be labeled

with the circuit number, which they are associated with, within three inches of their termination point

3.2 FIELD QUALITY CONTROL

A. The Contractor shall circuit the panelboards as shown on the drawings. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 10 percent, rearrange circuits in the panelboard to balance the phase loads within 10 percent.

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections.

**END OF SECTION**

# SECTION 262702

# EQUIPMENT WIRING

## PART 1 - GENERAL

### 1.1 SCOPE

A. Perform all Work required to provide and install the electrical connections indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment included in this Section may be specified under other Divisions and/or Sections, or furnished by Owner, including, but not limited to:
   1. HVAC motors, VFDs, and panels
   2. Plumbing motors, VFDs, and panels
   3. Elevators
   4. Kitchen Equipment
   5. Modular Furniture

### 1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

B. Section 260533 Raceway and Boxes for Electrical Systems.

C. Section 260519 Low-Voltage Electrical Power Conductors and Cables.

### 1.3 SUBMITTALS

A. Product Data: Provide data for cord and wiring devices.

### 1.4 COORDINATION

A. Coordinate all equipment requirements with the various contractors and the Owner. Review the complete set of drawings and specifications to determine the extent of wiring, starters, devices, etc., required.

## PART 2 - PRODUCTS

### 2.1 CORDS AND CAPS

A. Straight-blade Attachment Plug: NEMA WD 1.

B. Locking-blade Attachment Plug: NEMA WD 5.

C. Attachment Plug Configuration: Match receptacle configuration at outlet provided for equipment.

D. Cord Construction: Oil-resistant thermoset insulated multiconductor flexible cord with identified equipment grounding conductor, suitable for hard usage in damp locations.

E. Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

## 2.2 OTHER PRODUCTS

A. Refer to related sections for other product requirements.

# PART 3 - EXECUTION

## 3.1 INSPECTION

A. Verify that equipment is ready for electrical connection, wiring, and energization.

## 3.2 PREPARATION

A. Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

## 3.3 INSTALLATION

A. Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.

B. Make conduit connections to equipment using flexible PVC-coated metal conduit.

C. Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.

D. Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connection boxes.

E. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.

F. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated. Connect with conduit and wiring as indicated.

## 3.4 HVAC AND PLUMBING CONNECTIONS

A. Provide all power wiring including all circuitry carrying electrical energy from panelboard or other source through starters, variable frequency drives (VFDs), and disconnects to motors or to packaged control panels. Packaged control panels may include disconnects and starters and overcurrent protection. Provide all wiring between packaged control panels and motors.

B. VFD Installations: Install VFD input wiring and output wiring in separate conduit systems. Do not mix VFD input power and output power, or control wiring in a common raceway.

C. Provide 120 volts to each temperature control panel. Coordinate requirements with HVAC/DDC contractors.

D. Unless otherwise specified, all electrical motors and control devices such as aquastats, float and pressure switches, fan powered VAV boxes, switches, electro-pneumatic switches, solenoid valves and damper motors requiring mechanical connections shall be furnished and installed and wired by the Contractor supplying the devices.

E. Each motor terminal box shall be connected with a minimum 12", maximum 36" piece of flexible PVC-coated metal conduit to a fixed junction box. Conduit must be installed perpendicular to direction of equipment vibration to allow conduit to freely flex.

F. Check for proper rotation of each motor.

## 3.5 ELEVATOR CONNECTIONS

A. Provide fused disconnect switch with auxiliary contacts adjacent to elevator equipment room door. Locate on strike side of door. Provide one (1) for each unit.

B. Provide all power wiring from source through disconnect to elevator controller to motor.

C. Provide fused disconnect switch labeled "CAB LIGHTS" adjacent to power disconnect. Extend 120 volt circuit from source through lockable switch to controller. Provide one lockable switch and 120 volt circuit per unit.

D. Provide 3/4" conduit from controller to nearest telephone wiring closet with CAT-3 (min) four (4) pair cable.

E. Provide smoke detector in each elevator equipment room or space and at the top of the elevator shaft. Provide an addressable relay in the elevator machine room for connection to the elevator controller.

F. Provide smoke detector in each elevator lobby. Provide an addressable relay in the elevator machine room for designated floor recall and alternate floor recall for connection to the elevator controller.

G. Provide vaportight wall mounted fixture (per the luminaire schedule) and duplex receptacle 72" above elevator pit. Provide switch adjacent to access ladder, 36" above door sill. Provide 3-way switches, receptacle, lamp and lampholder on every other floor above lowest level.

H. All traveling cables, control stations, control station wiring and final control connections at the controller shall be furnished and installed under Division 14 Elevator Work.

I. Coordinate entire installation with Division 14 Contractor prior to rough-in.

## 3.6 MODULAR FURNITURE CONNECTIONS

A. Coordinate delivery of furniture electrical whips with the furniture vendor. Schedule early delivery of whips to allow timely installation prior to furniture delivery.

B. Coordinate furniture power and voice/data feed points with the furniture vendor prior to rough-in. Furniture vendor to provide dimensioned plans showing wall and floor box locations for furniture feeds. DO NOT dimension floor box locations from electrical plans.

C. Provide dedicated neutrals for each circuit serving furniture. DO NOT share neutrals. Furniture systems are considered non-linear loads; provide one (1) wire size larger neutrals than phase conductors (i.e. provide #10 AWG neutrals if #12 AWG phase conductors are used).

## 3.7 EQUIPMENT CONNECTION SCHEDULE

A. As indicated on the drawings.

**END OF SECTION**

# SECTION 262713

# ELECTRICITY METERING

## PART 1 - GENERAL

### 1.1 SCOPE

A. Perform all Work required to provide and install the utility metering requirements as well as metering/monitoring equipment for the Owner's use indicated by the Contract Documents with supplementary items necessary for proper installation.

### 1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

### 1.3 SUBMITTALS

A. Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe electrical characteristics, features, and operating sequences, both automatic and manual.

B. Dimensioned plans and sections or elevation layouts (if applicable).

C. Submit Utility Company prepared drawings (if applicable).

### 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.

### 1.5 OPERATION AND MAINTENANCE DATA

A. Field quality-control and test reports.

### 1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center according to NECA 400.

1.7 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:
   1. Comply with requirements of utilities providing electrical power services.
   2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

A. The following will be furnished by utility company:
   1. Meter
   2. Primary service
   3. Pad-mounted utility transformer
   4. Primary terminations at the utility transformer.

B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

C. Meter Sockets: Comply with requirements of electrical-power utility company.

D. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Contact Utility Company and make arrangements to obtain permanent electric service to the Project.

C. Utility transformer pad shall be furnished and installed by the contractor to the utility company's specifications.

D. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for primary cabling, metering leads and extend grounding connections as required by utility company.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in specification section 260553 Identification for Electrical Systems.

1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.
2. Equipment Identification Labels: Adhesive film labels with clear protective overlay. For residential meters, provide an additional card holder suitable for printed, weather-resistant card with occupant's name.

**END OF SECTION**

**SECTION 262726**

**WIRING DEVICES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following wiring devices indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment included in this Section
   1. Wall switches
   2. Receptacles
   3. Wall dimmers
   4. Device plates and box covers
   5. Poke-through service fittings

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

1.3 SUBMITTALS

A. Provide product data showing model numbers, configurations, finishes, dimensions, and manufacturer's instructions.

1.4 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state, and local requirements, and shall conform to codes and ordinances of authorities having jurisdiction.

B. Provide factory fabricated wiring devices in the type and electrical rating for the service indicated. Where type and grade are not indicated provide proper selection to correspond with branch circuit wiring and overcurrent protection.

C. Attachment of wires to devices shall be by screw pressure under the head of binding screws. Arrangements depending on spring pressure or tension are not acceptable. All binding screws shall be brass or bronze.

D. See Drawings for Device Schedule.

## 2.2 DEVICE COLOR

A. Ivory White, unless noted otherwise.

## 2.3 WALL SWITCHES

A. Wall Switches for Lighting Circuits and Motor Loads Under 1/2 HP: Quiet-type single pole through four (4)-way.

B. Heavy duty use toggle switch, nylon or high impact resistant face and body, rated 20 amperes and 120/277 volts AC.

C. Switches shall be UL20 Listed and meet Federal Specification WS-896. All switches shall be heavy duty Specification Grade with separate green ground screw.

D. All switches shall be back and side wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG.

## 2.4 KEYED SWITCHES

A. Keyed switches shall have the same requirements as wall switches except for a key operator in lieu of a toggle switch.

B. Provide one (1) key per switch to the Owner.

## 2.5 TAMPER RESITANT STRAIGHT-BLADE RECEPTACLES

A. Nylon or high impact resistant face, NEMA configuration as scheduled on the Drawings.

B. Receptacles shall be UL498 Listed and meet Federal Specification WC-596.

C. All receptacles shall be back and side wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with a separate green ground screw. Connector-type receptacles are also acceptable.

## 2.6 TWIST LOCK RECEPTACLES

A. Nylon or high impact resistant face, NEMA configuration as scheduled on the Drawings.

B. Receptacles shall be UL498 Listed and meet Federal Specification WC-596.

C. All receptacles shall be back and side wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with a separate green ground screw.

## 2.7 GROUND FAULT CIRCUIT INTERRUPTER (GFCI) RECEPTACLES

A. Duplex convenience receptacle, Specification Grade, with integral ground fault current interrupter, auto monitoring (self-test), and line-load reversal function meeting the requirements of UL standard 943 Class A and UL standard 498.

B. All receptacles installed in outdoor locations, in garages, within six (6) feet of the outside edge of sinks, and in other damp or wet locations shall be GFCI type.

## 2.8 COMBINATION USB CHARGER RECEPTACLES

A. Standard AC duplex tamper resistant receptacle with two (2) USB charging ports (Type-A and/or Type-C as noted in the schedule) rated at a minimum of 3.0 A at 5 VDC, UL Listed to UL 498 and UL 1310.

B. Receptacle shall be UL 498 and UL 1310 Listed and meet Federal Specification WC596.

C. USB ports shall work with USB 2.0, 3.0, and 3.1 compatible devices.

D. Device shall have auto grounding feature.

E. Receptacle shall be back and side wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with a separate green ground screw.

## 2.9 SPECIFIC USE RECEPTACLE

A. Configuration: As indicated on drawings.

## 2.10 WALL DIMMERS

A. Wall Dimmers: Linear slide type or electronic to match the load served. Loads may include the following:
   1. LED lighting

B. Rating: 600 Watts minimum, larger size to accommodate load shown on Contract Drawings.

## 2.11 DEVICE PLATES AND BOX COVERS

A. Cover Plate
   1. Finished Spaces: Smooth thermoplastic nylon.

2. Unfinished Spaces: Smooth thermoplastic nylon.
3. Mechanical and Electrical Rooms: Galvanized Note requirement for red plates on emergency outlets.

B. Weatherproof Cover Plate: Gasketed plastic with hinged cover, wet location listed while in use.

## 2.12 POKE-THROUGH FITTINGS

A. Description: These poke-thru devices provide the interface between power, communication and audio/visual (A/V) cabling in an above grade concrete floor and the workstation or activation location where power communication and/or A/V device outlets are required.

B. Classification and Use: This poke-thru device shall have been examined and tested by Underwriters Laboratories Inc. to Standard UL514A and/or UL514C and Canadian Standard C22.2, No. 18-98 and bear the U.S. and Canadian UL Listing Mark. This poke-thru device shall also have been tested by Underwriters Laboratories Inc. and classified for fire resistance and bear the U.S. and Canadian UL Classification Mark. Devices shall be classified for use in 1-, 1 1/2-, or 2-hour rated, unprotected reinforced concrete floors and 1-, 1 1/2-, or 2-hour rated, unprotected reinforced concrete floors and 1-, 1 1/2-, or 2-hour rated floors employing unprotected steel floor units and concrete toppings (D900 Series Designs) or concrete floors with suspended ceilings (fire resistive designs with suspended ceilings should have provisions for accessibility in the ceiling below the poke-thru fittings. This device shall also conform to the standards set in the National Electric Code, Section 300-21. These devices meet all UL scrub water requirements, but are not suitable for wet or damp locations, or other areas subject to saturation with water or other liquids such as commercial kitchens. This poke-thru device shall also have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors. Suitable for use in air handling spaces in accordance with Sec 300-22 (C) of the National Electrical Code.

C. Fire Rating: Three (3) hours or as noted on the plans.

D. Service Fitting: See plans.

E. Type: Flush. See plans.

F. Housing: Brushed Nickel See plans.

G. Device Plate: Stainless steel

H. Configuration: See plans for configuration.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. All dimensions noted are centerline dimensions.

B. Install wall switches 42 inches above floor, OFF position down.

C. Install wall dimmers 42 inches above floor; de-rate ganged dimmers as instructed by manufacturer; do not use common neutral.

D. Install convenience receptacles 18 inches above floor, 6 inches above counters or backsplash, grounding pole on bottom. Mount horizontally where indicated.

E. Install boxes for information outlets 18 inches above finished floor. Install boxes for telephone jack for wall telephones 54 inches above finished floor.

F. Install specific-use receptacles at heights shown on Contract Drawings.

G. Poke-through device installation: Unit shall permit all wiring to be completed at floor level. Use is defined by the UL Fire Resistance Directory as a minimum spacing of "two (2) ft. (610 mm) on center and not more than one (1) device per each 65 sq. ft. (6 m²) of floor area in each span." Installation shall be completed by pushing unit down into the cored hole. Prior to and during installation, refer to system layout and/or approval drawings. Installer shall comply with detailed manufacturer's instruction sheet included with each device. The unit shall contain a retainer for securing the device in the slab, as well as the necessary intumescent material to seal the cored hole under fire conditions.

H. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

I. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

J. Install devices and wall plates flush and level.

K. Receptacles shall have a bonding conductor from grounding terminal to the metal conduit system. Self-grounding receptacles using mounting screws as bonding means are not approved.

## 3.2 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify that each receptacle device is energized.

D. Test each receptacle device for proper polarity.

E. Test each GFCI receptacle device for proper operation.

3.3 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

B. Mark all conductors with the panel and circuit number serving the device with a machine generated label, at the device, and on the back of the device cover.

**END OF SECTION**

**SECTION 262728**

**DISCONNECT SWITCHES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install disconnect switches, fuses and enclosures indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

1.3 SUBMITTALS

A. Include outline drawings with dimensions, and equipment ratings for voltage, ampacity, horsepower, and short circuit.

1.4 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES

A. Fusible Switch Assemblies (use only when overcurrent protection is required): NEMA Type Heavy Duty; quick-make, quick-break, load interrupter, enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: designed to accommodate Class R cartridge type fuses.

B. Nonfusible Switch Assemblies: NEMA Type Heavy Duty; quick-make, quick-break, load interrupter, enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

C. Provide auxiliary contacts on fusible switches serving elevator controllers.

D. Solid neutral bus when neutral conductor is included with circuit.

E. Provide manufacturer's equipment ground kit in all disconnect switches.

F. Enclosure: NEMA Type as indicated on Drawings.

G. Current rating and number of poles as indicated on drawings.

2.2 FUSES

A. Fuses 600 Amperes and Less: Dual element, time delay, 600 volt, UL Class RK 5. Interrupting Rating: 200,000 rms amperes.

B. Fuses 601 Amperes and Larger: Time delay, 600 volt, UL Class L. Interrupting Rating: 200,000 rms amperes.

C. Provide three (3) spares of each size and type fuse. Provide enclosure for spare fuse.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install disconnect switches where indicated on Drawings.

B. Install switches so that the maximum height above the floor to the center of the operating handle does not exceed 6'-6".

C. Provide conduit and wiring from the auxiliary contacts on the elevator disconnect switch to the elevator controller. Coordinate installation with the elevator vendor.

D. Provide identification as specified in Section 260553.

**END OF SECTION**

# SECTION 262900

# MOTOR CONTROLLERS

## PART 1 - GENERAL

### 1.1 SCOPE

A. Perform all Work required to provide and install manual motor starters, magnetic motor starters, combination magnetic motor starters and motor control centers indicated by the Contract Documents with supplementary items necessary for proper installation.

### 1.2 REFERENCES

A. Applicable provisions of Division 1 shall govern work under this Section.

B. Section 260529 – Hangers and Supports for Electrical Systems.

C. ANSI/NEMA ICS 6 Enclosures for Industrial Controls and Systems.

D. ANSI/UL 198E Class R Fuses.

E. NEMA AB 1 Molded Case Circuit Breakers.

F. NEMA ICS 2 Industrial Control Devices, Controllers, and Assemblies.

G. NEMA KS 1 Enclosed Switches.

H. NEMA PB 1 Panelboards.

I. NEMA PB 1.1 Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

### 1.3 SUBMITTALS

A. Indicate on shop drawings, front and side views of motor control center enclosures with overall dimensions. Include conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time current curves of all equipment and components.

B. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and overcurrent protective devices.

1.4 COORDINATION WITH OTHER TRADES

A. Motors: In general, all electric motors required for this installation will be supplied with equipment, apparatus and/or appliances covered under other sections of the Specifications.

B. For the sake of consistency and conformity of manufacturer, design and construction, all motors shall conform to the following description unless otherwise noted or required.
   1. Motors 3/4 HP and smaller shall be wound for operation on single phase, 60 Hz. service unless otherwise noted.
   2. Motors 1 HP and above shall be wound for operation on 3 phase, 60 Hz service unless otherwise noted.
   3. Refer to drawings in each case in order to verify voltage characteristics required.

C. Equipment:
   1. All building utility motors such as fans, pumps, overhead doors, etc., together with certain "controlling equipment" for same, except motor starters and related apparatus, will be furnished under other sections of the specifications and delivered to the building site unless specifically noted otherwise. The above mentioned "controlling equipment" pertains to electrical thermostats, electro-pneumatic and pneumatic-electric and detection devices, or any other device not purely electrically operating in nature.

D. The starters for these motors shall be furnished and installed by the Electrical Trade unless noted otherwise. (See mechanical equipment schedules on Drawings.)

E. The Electrical Trade shall set and connect all specified starting equipment, install all power conduits and wiring and shall furnish and make all connections from starting equipment to motors as required to leave the apparatus in running condition.

F. Wiring Connections:
   1. Furnish branch circuits for all motors to the starting equipment and then to the motors, complete with all control wiring for automatic and remote control where required or noted. Conduits to motors shall terminate in the conduit fittings on the motors, the final connection being made with flexible, PVC-coated metal conduit.

G. Provide all necessary labor and material to completely connect all electrical motors and controls (where required) in connection with the building utility equipment, including fans, pumps, overhead door operators, etc.

H. All conduits and wiring required for control work from the holding coil circuit of the starter, including the furnishing and installation of control devices such as auxiliary contacts, control relays, time delay relays, pilot lights, selector switches, alternators, etc., shall be provided and installed by other trades unless otherwise indicated.

I. Power Branch Circuits:
   1. Wire sizes for branch circuits not specifically called for on drawings or in specifications shall be based on 125 percent of the full load current of the motor unless the voltage drop of motor branch circuits exceeds 1-1/2 percent from the distribution panel to the motor; in which case, voltage drop shall govern wire sizes. A power factor of 80 percent shall be used for motors in such calculations.

1.5 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

1.7 SPARE PARTS

A. Keys: Furnish two (2) each to Owner.

PART 2 - PRODUCTS

2.1 MANUAL MOTOR STARTERS

A. Manual Motor Starter: NEMA ICS 2; size as shown on Drawings. AC general-purpose Class A manually operated full-voltage controller for induction motors rated in horsepower, with overload protection, toggle operator, red pilot light and handle lock.

B. Enclosure: NEMA Type: 1. As indicated on the drawings.

C. Provide manufacturer’s equipment ground kit in all starter enclosures.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions.

B. Motor Starter Panelboard Installation: In conformance with NEMA PB 1.1.

C. Select and install heater elements in motor starters to match installed motor characteristics.

D. Connect hand-off auto selector switches so that automatic control only is by-passed in "manual" position and any safety controls are not by-passed.

E. Install manual motor starters in flush enclosures in finished areas.

F. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

## 3.2 TESTING

A. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections and electrical tests:
   1. Visual and Mechanical Inspection
      a. Compare equipment nameplate data with specifications and approved shop drawings.
      b. Inspect physical, electrical, and mechanical condition.
      c. Inspect contactors.
      d. Clean motor starters.
      e. Verify overload element/unit ratings are correct for their applications.
      f. If motor-running protection is provided by fuses, verify correct fuse rating.
      g. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data.

**END OF SECTION**

**SECTION 263200**

**GENERATORS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all work required to relocate an existing 230kW/288kVA Kohler generator owned by the county. Relcoate the packaged engine generator system with controls and startup testing indicated by the Contract Documents with supplementary items necessary for proper installation. Rewire alternator for 277/480V output voltage.

B. Equipment included in this Section:
   1. Existing generator assembly:
      a. Genset Model: 230REOZJE
      b. Spec Number: GM66100 – GA4
      c. Serial Number:33C3GMKN0011
      d. Material: 230REOZJE – CP1
      e. Voltage: 120/208 (currently) – rewire for 277/480
      f. Alt Model: 4UA13
      g. Insulation: H
      h. MFG Date: 11/23/2022
      i. Amps: 798
      j. Phase: 3
      k. RPM: 1800
      l. Battery: 24V
      m. PF: 0.8
      n. Hz: 60
      o. Fuel Tank: 944 Gallon (dual walled belly tank)
   2. Remote control panel.

C. The engine generator emergency system operates in coordination with the automatic transfer switches to provide power in the event of failure of the normal power source.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this section.

B. Section 263600 - Transfer Switches.

C. NFPA110 – Emergency and Standby Power Systems.

D. ANSI/NEMA MG 1 - Motors and Generators.

E. NFPA 37 - Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines

F. NFPA 70 – National Electric Code

## 1.3 SUBMITTALS

A. Product Data:
   1. None required.

B. Shop Drawings:
   1. None Required

C. Informational Submittal:
   1. Source Quality-Control Reports: Including, but not limited to, the following:
      a. Provide a load test on the existing generator and submit the report, documenting evidence of compliance with specified requirements.
      b. Air Quality Construction Permit: Provide completed application for submittal. Include approximate fees and certification.

D. Closeout Submittal:
   1. Operation Data: Include instructions for normal operation.
   2. Maintenance Data:
      a. Include instructions for routine maintenance requirements, service manuals for engine and fuel system, oil sampling and analysis for engine wear, and emergency maintenance procedures.
      b. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

## 1.4 PERMITS

A. The Contractor shall be responsible for obtaining all necessary permits for the complete installation of the generator fuel system and related equipment. The contractor shall arrange to have a certified tank installer supervise and certify the fuel system installation.

## 1.5 EXTRA MATERIAL

A. None

## 1.6 WARRANTY

A. None

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Kohler (Existing to be relocated)

2.2 SYSTEM RATINGS

A. Generator Set Rating (existing): 230kW, 288kVA, .8pf lagging, 480/277, VAC, 3 phase, 4 wire, 12 wire re-connectable, 60 Hz at 1,800 rpm.

B. Power Rating: Standby

2.3 ENGINE and Accessories:

A. Engine Type: Water-cooled, four cycle, internal combustion engine.

B. Fuel Type: No. 2 diesel fuel

C. Generator Emergency Stop Pushbutton:
   1. Provide new Mushroom head pushbutton with enclosure rated NEMA 3R. Engraved nameplate shall read “Generator Emergency Stop”.
   2. Provide tamper-proof cover.

D. Generator Remote Annunciator Panels:
   1. Provide new annunciator panel compatible with generator and install in Maintenance building as shown on plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine rough-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Equipment Mounting:
   1. Install engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
   2. Coordinate size and location of concrete bases for engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Contractor shall provide all required fuel during testing and a full tank of fuel at the time of Substantial Completion of the project.

## 3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding."

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cable." Provide flexible conduit routed to the engine generator from a stationary element.

## 3.4 IDENTIFICATION

A. Identify system components in accordance with Section 260553 "Identification."

B. Install a sign indicating the generator is installed as a separately derived source per NFPA 70.

## 3.5 FIELD QUALITY CONTROL

A. Testing Agency:
   1. Owner will engage a qualified testing agency to perform tests and inspections.
   2. Engage a qualified testing agency to perform tests and inspections.
   3. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
   4. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:
   1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs below as specified in the NETA ATS. Certify compliance with test parameters.
      a. Visual and Mechanical Inspection:
         1) Compare equipment nameplate data with drawings and specifications.
         2) Inspect physical and mechanical condition.
         3) Inspect anchorage, alignment, and grounding.
         4) Verify the unit is clean.
      b. Electrical and Mechanical Tests:
         1) Verify phase rotation, phasing, and synchronized operation as required by the application.

2) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
3. After the generator has cooled down from the NFPA 110 Acceptance Test, shut it down and then simulate a power failure including operation of the transfer switch, automatic cycle, and automatic shutdown and return to normal.
4. Battery Tests: Equalize charging of battery cells in accordance with manufacturer's written instructions. Record individual cell voltages.
   a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
   b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
   c. Verify acceptance of charge for each element of the battery after discharge.
   d. Verify that measurements are within manufacturer's specifications.
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 percent step-load increases and decreases and verify that performance is as specified.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments will have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, inspect exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safety. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. 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.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after relocation, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load.
   1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   2. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

## 3.6 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercises to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

## 3.7 TRAINING

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

B. Provide eight (2) hours on-site training.

**END OF SECTION**

**SECTION 263600**

**TRANSFER SWITCHES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the transfer switches (less than 600V) for standby generator systems indicated by the Contract Documents with supplementary items necessary for proper installation. The transfer switch(es) shall start and stop the generator.

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this section

B. Section 26 32 00 - Generator

C. UL 1008 – Transfer Switch Equipment

D. NFPA 110 – Emergency Standby Systems

E. NFPA 70 – National Electrical Code

1.3 SUBMITTALS

A. Submit product data showing overall dimensions, electrical connections, electrical ratings, all specified accessories, interlock methods, and environmental requirements.

B. Submit manufacturer's installation instructions.

1.4 QUALITY ASSURANCE

A. Manufacturer: Company specializing in automatic transfer equipment with five (5) years documented experience.

1.5 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

B. In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

C. Instructions for operating equipment under test and emergency conditions.

## PART 2 - PRODUCTS

### 2.1 AUTOMATIC TRANSFER SWITCH

A. Description: NEMA ICS 10; automatic transfer switch. In applications where the switch serves as the service entrance disconnect, the switch shall be rated as suitable for use as a service disconnecting means.

B. Configuration: The transfer switch shall be electrically operated and mechanically held. The electrical operation shall be by a solenoid mechanism operating from the same source to which the load is being transferred.

C. The switch shall be rated for continuous duty and be mechanically interlocked to be in either the normal or the emergency position.

D. The switch shall be controlled by electronic solid state components with printed circuit control boards, and industrial grade plug in control relays.

E. The switch shall be designed and built so that it can be manually operated under no-load conditions from behind a barrier partition or with the door closed. The enclosure shall allow for inspection of the internal operation of the switch through a full sequence of the transfer cycle with the door open and the switch de-energized.

F. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two (2) working switch positions, with an intentional, time-controlled pause at midpoint during transfer.

G. Unassigned Auxiliary Contacts: Two (2) normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

### 2.2 RATINGS

A. Ratings: As scheduled on the Drawings.

### 2.3 AUTOMATIC SEQUENCE OF OPERATION

A. Initiate Time Delay to Start Alternate Source Engine Generator: Upon initiation by normal source monitor.

B. Time Delay to Start Alternate Source Engine Generator: 0 to 10 seconds, adjustable.

C. Initiate Transfer Load to Alternate Source: Upon initiation by normal source monitor and permission by alternate source monitor.

D. Time Delay Before Transfer to Alternate Power Source: 0 to 60 seconds, adjustable.

E. Initiate Re-transfer Load to Normal Source: Upon permission by normal source monitor.

F. Time Delay Before Transfer to Normal Power: 0 to 30 minutes adjustable.

G. Time Delay Before Engine Shut Down: 0 to 30 minutes, adjustable, unloaded operation.

H. Operating transfer time of the switch in either direction shall not be greater than 1/6 of a second.

I. Engine Exerciser: Digital control, - start engine every 7 to 30 days adjustable; run for 0 to 120 minutes adjustable, before shutting down. Bypass exerciser control if normal source fails during exercising period.

## 2.4 ACCESSORIES

A. Manual Operator: Provide manual operator to allow switch to be operated under no-load conditions from behind a barriered partition or with the door closed.

B. Indicating Lights: LED type. Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, ALTERNATE SOURCE AVAILABLE, SWITCH POSITION.

C. Maintained Keyed Test Switch: Mount in cover of enclosure to simulate failure of normal source by interrupting the power signal to the normal source monitor. Switches shall be keyed alike for all transfer switches. Provide two keys for each transfer switch.

D. Return to Normal Switch: Mount in cover of enclosure to initiate manual transfer from alternate to normal source.

E. Transfer Switch Auxiliary Contacts: Minimum two (2) normally open; two (2) normally closed.

F. Normal Source Monitor: Monitor each line of normal source voltage; adjustable set points; initiate transfer when voltage drops below 85 percent.

G. Alternate Source Monitor: Monitor alternate source voltage and frequency; adjustable set points; inhibit transfer when voltage is below 85 percent or frequency varies more than 3 Hertz from rated nominal voltage.

H. The switch shall contain an in-phase monitor or adjustable time delay transition to inhibit closing of the switch into high levels of motor residual voltage.

I. A factory installed equipment ground bar shall be provided in each switch enclosure.

J. Four-pole transfer switches shall contain an overlapping neutral contact or a fully rated switched neutral pole.

K. Three-pole transfer switches shall contain a factory installed fully rated solid neutral lug assembly.

L. Provide digital metering on all transfer switches 200A and larger. Metering shall provide, at a minimum, measurement of voltage, current and kW demand for each phase on the load side of the switch.

M. Provide engine start monitoring (ESM) modules, conduit and wiring as required for compliance with NEC Article 700.10(D)(3).

## 2.5 TRANSFER SWITCH REMOTE ANNUNCIATOR PANEL

A. Remote annunciator panel with a minimum of 6 channels for monitoring and controlling the automatic transfer switches installed on the campus.

B. Surface mounted NEMA 1 enclosure.

C. LED indicators (source availability, time delay, switch position, transfer test), audible alarm, alarm silence button, and key lock for securing control functions.

## 2.6 ELEVATOR CONTROL INTERFACE ACCESSORIES

A. Transfer switches serving elevators shall be provided with auxiliary contacts designed to provide emergency system status to the elevator controllers. These contacts are in addition to the contacts required elsewhere in this specification.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Starting contacts for all transfer switches shall be wired in parallel to the generator starting circuit so that any transfer switch that senses a loss of normal power will start the generator. This includes contacts as part of the fire pump controller. This control wiring is not shown on the plans but is required to be provided by the electrical contractor.

C. Wiring between the elevator control contacts and the elevator controllers is not shown on the plans but is required to be provided by the electrical contractor. Terminations at the elevator controller shall be by the elevator installer.

## 3.2 FIELD ADJUSTMENTS

A. The contractor shall field adjust all timing and voltage settings of the transfer switch as necessary for proper operation of the switch, related loads and sources.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. Provide functional testing in conjunction with testing requirements outlined in Section 263200 – Generators.

3.4 TRAINING

A. Provide training in conjunction with training provided in Section 263200 – Generators.

**END OF SECTION**

**SECTION 264113**

**LIGHTNING PROTECTION FOR STRUCTURES**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following lightning protection for structures indicated by the Contract Documents with supplementary items necessary for proper installation. The work under this section includes a UL Master Label lightning protection system for the new building.

1.2 REFERENCES

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

B. The materials and installation shall conform to the minimum requirements and latest revisions of the following codes, standards and regulations wherein they apply:
   1. NFPA 70 - National Electrical Code
   2. UL 96 - Lightning Protection Components
   3. UL 96A – Installation Requirements for Lightning Protection Systems
   4. NFPA 780 – Standards for the Installation of Lightning Protection Systems
   5. LPI 175 - Standard of Practice for the Design - Installation - Inspection of Lightning Protection Systems

1.3 SUBMITTALS

A. Product Data
   1. Submit complete descriptive information on all materials and installation methods. Product data showing dimensions and materials of each component and include indication of Listing in accordance with UL 96.

B. Shop Drawings: For air terminals and mounting accessories.
   1. Detailed plan drawings shall be prepared which indicates all Work to be performed.
   2. Shop drawings shall include locations of conductors, roof penetrations, floor penetrations, etc., and their compatibility with provisions made during the construction. Once the contract has been established the Contractor shall make a review of provisions being made for the system installation and comment, in writing, with changes or compliance within two weeks of finalizing the contract. Contractor shall coordinate locations of conductors in walls and all penetrations with the appropriate trades. Failure to coordinate these requirements shall not relieve lightning protection Contractor from properly completing its work. This Contractor shall employ the proper trades to provide

the chases in walls and roof and floor penetrations required to install the conductors if not coordinated before the floors, walls and roof are installed.

3. Manufacturer's catalog numbers and generic identification shall be indicated for all components shown on the Drawings.
4. Record Drawings: The Contractor shall maintain a master set of Record Drawings that shows changes and any other deviations from the approved shop drawings including location of ground rods and ground loop conductors.

C. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.

D. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.

## 1.4 QUALITY ASSURANCE

A. Manufacturer: Company specializing in lightning protection equipment with a minimum of three years documented experience and material compliance with UL requirements.

B. Contractor Qualifications
1. The Contractor for the Work covered by this Specification shall be one that is recognized as being regularly engaged in the design and installation of lightning protection systems.
2. The Contractor must be listed by Underwriters Laboratories, Inc., and must employ competent personnel fully qualified in the field of lightning protection. The Contractor must have minimum ten years documented experience.

C. Master Label
1. The system design and installation shall meet or exceed the requirements of UL 96A and NFPA 780 for a Master Label.
2. Upon completion, the lightning protection system shall be inspected by a representative of Underwriters Laboratories Provide UL Master Lanel Certificate issued by UL solutions or an approved third-party inspection agency.
3. The lightning protection system must pass the UL inspection. If the system does not pass inspection, the Contractor must make corrections to the system to pass inspection.

## 1.5 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

C. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. ERICO International Corporation

B. Harger Lightning & Grounding

C. Heary Bros. Lightning Protection Co. Inc.

D. Independent Protection Co.

E. Preferred Lightning Protection

F. Robbins Lightning, Inc.

G. Thompson Lightning Protection, Inc.

H. East Coast Lightning Equipment Inc.

2.2 GENERAL

A. Comply with UL 96 and NFPA 780 for use on Class I structures.

B. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

C. The system provided under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems and shall be the manufacturer's latest approved design.

D. Listing of the manufacturer in the lightning protection section of the current edition of Underwriters' Laboratories, Inc., Electrical Construction Materials List will be accepted as compliance with this requirement.

E. Materials used in connection with the installation of the lightning protection system shall be approved for lightning protection systems by the Underwriters' Laboratories, Inc.

F. No combination of materials shall be used that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture.

G. Where unusual conditions exist, which would cause deterioration or corrosion of conductors, conductors with suitable protective coatings or oversize conductors shall be used.

H. If a mechanical hazard is involved, the conductor size shall be increased to compensate therefore, or suitable protection shall be provided.

I. The conductors may be protected by covering them with molding or tubing made of nonmagnetic material.

J. Aluminum materials may not be used except on roofs that utilize aluminum roofing components. When aluminum materials are used, provide all materials of aluminum composition to ensure compatibility, except down conductors and grounding. Aluminum conductors, when used, shall be electrical-grade.

## 2.3 AIR TERMINALS

A. Class I
   1. Solid copper with pointed tip, minimum diameter of 3/8".
   2. Minimum 18" long. Air terminals more than 24" long shall have a brace attached to the terminal at not less than half the height of the terminal.
   3. Where longer air terminals are required, solid rods of the appropriate length with threaded ends may be securely attached to the air terminals for extensions.
   4. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in Division 07 roofing sections.

## 2.4 CONDUCTORS

A. All conductors shall be stranded or braided copper and of the grade ordinarily required for commercial electrical work generally designated as being 95 percent conductive when annealed. Stranded or braided aluminum conductors shall be used on roofs that utilize aluminum components. Aluminum conductors shall be immediately transitioned to copper conductors by using appropriate bimetal connectors, as soon as they depart from aluminum surfaces.

B. Conductor minimum sizes are per NFPA 780.

C. Ground Loop Conductor: The same size and type as the main conductor except tinned.

## 2.5 GROUND RODS

A. Copper-clad steel; 3/4" in diameter by ten (10) feet.

## 2.6 GROUNDING ACCESSORIES/CONNECTIONS

A. Ground Plates: Solid copper, not less than 20 gauge.

B. Bonding Plates: Bronze, 8 square inches

C. Through-Roof Connectors: Solid copper riser bar, length and type as required to accommodate roof structure and flashing requirements. Fittings shall incorporate a positive means for sealing around the penetration.

D. Anchors and Fasteners: Bronze bolt and clamp-type shall be used for all applications except for membrane roof. Adhesive type are allowed only for attachment to membrane roof materials, using adhesive that is compatible with the membrane material.

E. Connectors: Bronze clamp-type connectors shall be used for roof conductor splices, and the connection of the roof conductor to air terminals and bonding plates. Crimp-type connectors are not allowed.

F. Exothermic Welds: Exothermic welds shall be used for splicing the roof conductor to the down conductors, splices of the down conductors, and for connections of the down conductor to ground rods, ground plates, and the ground ring.

G. Down Conductor Guards: Stiff copper or brass

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Design and provide a complete lightning protection system consisting of air terminals, conductors, connectors, attachments, ground ring electrode, grounding, bonding and necessary appurtenances to comply with minimum requirements listed in the referenced standards.

B. The system shall be installed in a neat workmanlike manner and without interfering with other building systems.

C. Verify that surfaces are ready to receive work, and field measurements are as shown on the shop drawings. Beginning of installation means installer accepts existing conditions.

D. Protect elements surrounding work of this Section from damage or disfiguration.

E. Coordinate installation with the roofing manufacturer and roofing installer. The Contractor shall submit details of all roof attachments and penetrations to the appropriate roof manufacturer for approval prior to installation.

F. Coordinate roof penetrations with Architectural Drawings.

### 3.2 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. The installation shall be in accordance with manufacturer’s published recommendations.

C. Install conductors with direct paths from air terminals to ground connections.

D. Maintain horizontal or downward coursing of main conductor and ensure that all bends have at least an 8” radius and do not exceed 90 degrees.

E. Secure conductors to the roof or other structure at a maximum interval of 3 feet.

F. Make connections of dissimilar metal with bimetallic-type fittings to prevent electrolytic action.

G. Conceal the following conductors:
   1. System conductors
   2. Down conductors
      a. Concealed down conductors shall be installed in continuous, insulating PVC raceways. Metallic raceways shall not be used.
      b. Down conductors being installed on existing buildings may be run on the exterior of the building.
   3. Conductors within normal view of exterior locations at grade within 200 feet of building.

H. Air terminal installation shall be designed and braced for 100-mph winds with 125-mph gusts.

I. Install air terminal bases, cable holders, and other roof-system supporting means without piercing the roof membrane or metal roof.

J. Air terminal bases on single-ply membrane roofing shall comply with roofing membrane and adhesive manufacturer's written instructions.

K. Use through-roof connectors for penetrations of the roof system. Flashing shall be provided by the roofing contractor.

L. Down conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel or the structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 100 feet.

M. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

N. Where down conductors are subject to damage or are accessible near grade, protect with down conductor guards to 8 feet above grade. Bond down conductor guards to down conductor at both ends.

O. Install ground rods and plates not less than 2 feet deep and a distance of not less than 3 feet, nor more than 8 feet, from the nearest point of the structure. Exothermically weld the down conductors to ground rods and ground plates.

P. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure where shown.
   1. Bury ground ring not less than 2 feet deep and a distance of not less than 3 feet, nor more than 8 feet, from the nearest point of the structure.
   2. Bond ground terminals to the ground loop. Ground connections to earth shall not exceed 60’ intervals around the perimeter of the building.
   3. Bond grounded building systems to the ground loop conductor within 12 feet of grade level.

Q. In the event a conflict exists between this Specification and any of the referenced standards, the requirements of referenced standards govern. Necessary variances or corrections shall be made at the expense of the lightning protection contractor in order to obtain UL Master Label.

## 3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

## 3.4 FIELD QUALITY CONTROL

A. Notify Engineer at least 2 weeks in advance of inspection before concealing lightning protection components.

B. Once the lightning protection system installation is complete, the Contractor shall engage the appropriate roof manufacturer to inspect all roof attachments and penetrations on that manufacturer's roof.
   1. Subsequent to the inspection, the roof manufacturer shall furnish the Owner with a letter indicating that all lightning protection system component roof attachments and penetrations are satisfactory and that such attachments and penetrations will not in any way reduce the manufacturer's warranty on the roof.
   2. Any fees for services or inspections provided by the roof manufacturer to accomplish the above related requirements shall be at the expense of the Contractor.

C. A UL representative shall inspect the lightning protection system. Obtain and install a UL Master Label for each lightning protection system at the location directed by the Owner.

**END OF SECTION**

**SECTION 264313**

**SURGE PROTECTION DEVICES (SPDs)**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install surge protection devices (SPD) as indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable UL standard (ANSI/UL 1449 3rd Edition).

B. IEEE C62.41 Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

1.3 SUBMITTALS

A. The following information shall be submitted to the Engineer:
   1. Product data and manufacturer's installation instructions.

B. Provide verification that the SPD complies with the required ANSI/UL 1449 3rd Edition listing by Underwriters Laboratories (UL) or other Nationally Recognized Testing Laboratory (NRTL). Compliance may be in the form of a file number that can be verified on UL's website or on any other NRTL's website, as long as the website contains the following information at a minimum:
   1. Model number.
   2. SPD Type.
   3. System voltage, phases.
   4. Modes of protection.
   5. Voltage Protection Rating (VPR).
   6. Nominal Discharge Current (In).

C. For sidemount mounting applications (SPD mounted external to electrical assembly), electrical/mechanical drawings showing unit dimensions, weights, installation instruction details, and wiring configuration.

1.4 QUALITY ASSURANCE

A. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years.

B. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

C. The specified system shall be thoroughly factory tested before shipment. Testing of each system shall include but shall not be limited to quality control checks, dielectric voltage withstand tests at twice rated voltage plus 1000 volts per UL requirements, and operational and calibration tests.

1.5 SUMMARY

A. The Contractor shall furnish and install the Surge Protective Device (SPD) equipment having the electrical characteristics, ratings, and modifications as specified herein and as shown on the contract drawings. To maximize performance and reliability and to obtain the lowest possible let-through voltages, the ac surge protection shall be integrated into electrical distribution equipment such as switchgear, switchboards, panelboards, busway (integrated within bus plug), or motor control centers.

1.6 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.

B. Section 262416 – Panelboards

1.7 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer’s instructions.

1.8 OPERATION AND MAINTENANCE MANUALS

A. Operation and maintenance manuals shall be provided with each SPD shipped.

1.9 WARRANTY

A. The manufacturer shall provide a full five (5) year warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national or local electrical codes. Manufacturer shall make available field engineering service support.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. Siemens

C. General Electric

D. Eaton Cutler-Hammer

E. Mersen

F. Erico/Critec

G. Liebert

H. Current Technology

2.2 VOLTAGE SURGE SUPPRESSION – GENERAL

A. Electrical Requirements

1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.

2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 125% of the nominal system operating voltage.

3. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

| | Protection Modes | | | |
|---|---|---|---|---|
| Configuration | L-N | L-G | L-L | N-G |
| Wye | ● | ● | ● | ● |
| Delta | N/A | ● | ● | N/A |
| Single Split Phase | ● | ● | ● | ● |
| High Leg Delta | ● | ● | ● | ● |

4. Nominal Discharge Current ($I_n$) – All SPDs applied to the distribution system shall have a 20kA $I_n$ rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an $I_n$ less than 20kA shall be rejected.

5. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed the following:

| Modes | 208Y/120 | 480Y/277 |
|---|---|---|
| L-N; L-G; N-G | 700 | 1200 |
| L-L | 1200 | 2000 |

B. SPD Design
1. Maintenance Free Design – The SPD shall be maintenance free and shall not require any user intervention throughout its life.
2. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV.
3. Electrical Noise Filter – Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method.
4. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
5. Monitoring Diagnostics – Each SPD shall provide the following integral monitoring options:
   a. Protection Status Indicators - Each unit shall have an indicator light that reports the status of the protection on each phase.
      1) For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional indicator light that reports the status of the protection elements and circuitry in the N-G mode.
      2) For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes.
   b. Remote Status Monitor – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.
   c. Audible Alarm and Silence Button – The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.
   d. Surge Counter – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of 50 ± 20A occurs.
      1) The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.

6. Overcurrent Protection
   a. The unit shall contain thermally protected MOVs. These thermally protected MOVs shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.
7. Fully Integrated Component Design – All of the SPD's components and diagnostics shall be contained within one discrete assembly.
8. Safety Requirements
   a. Sidemount SPDs shall be factory sealed in order to prevent access to the inside of the unit. Sidemount SPDs shall have factory installed phase, neutral, ground and remote status contact conductors factory installed and shall have a pigtail of conductors protruding outside of the enclosure for field installation.

## 2.3 SYSTEM APPLICATION

A. The SPD applications covered under this section include distribution and branch panel locations. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.

B. Surge Current Capacity – The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

| Minimum surge current capacity based on ANSI / IEEE C62.41 location category | | | |
|---|---|---|---|
| Category | Application | Per Phase | Per Mode |
| C | Service Entrance Locations (Switchboards, Switchgear, MCC, Main Entrance) | 250 kA | 125 kA |
| B | High Exposure Roof Top Locations (Distribution Panelboards) | 160 kA | 80 kA |
| A | Branch Locations (Panelboards, MCCs, Busway) | 120 kA | 60 kA |

C. SPD Type – all SPDs installed on the line side of the service entrance disconnect shall be Type 1 SPDs. All SPDs installed on the load side of the service entrance disconnect shall be Type 1 or Type 2 SPDs.

## 2.4 LIGHTING AND DISTRIBUTION PANEL REQUIREMENTS

A. The SPD application covered under this section includes lighting and distribution panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.
   1. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
   2. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
   3. The panelboard shall be capable of re-energizing upon removal of the SPD.
   4. The SPD shall be interfaced to the panelboard via a direct bus bar connection. Alternately, an SPD connected to a 30A circuit breaker for disconnecting purposes may be installed using short lengths of conductors as long as the conductors originate integrally to the SPD. The SPD shall be located directly adjacent to the 30A circuit breaker.

B. Sidemount Mounting Applications Installation (SPD mounted external to electrical assembly):
   1. Lead length between the breaker and suppressor shall be kept as short as possible to ensure optimum performance. Any excess conductor length shall be trimmed in order to minimize let-through voltage. The installer shall comply with the manufacturer's recommended installation and wiring practices.

## 2.5 ENCLOSURES

A. All enclosed equipment shall have NEMA 1 general purpose enclosures, unless otherwise noted. Provide enclosures suitable for locations as indicated on the drawings and as described below:
   1. NEMA 1 – Constructed of a polymer (units integrated within electrical assemblies) or steel (sidemount units only), intended for indoor use to provide a degree of protection to personal access to hazardous parts and provide a degree of protection against the ingress of solid foreign objects (falling dirt).
   2. NEMA 4 – Constructed of steel intended for either indoor or outdoor use to provide a degree of protection against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (dirt and windblown dust); to provide a degree of protection with respect to the harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water); and that will be undamaged by the external formation of ice on the enclosure. (sidemount units only)
   3. NEMA 4X – Constructed of stainless steel providing the same level of protection as the NEMA 4 enclosure with the addition of corrosion protection. (sidemount units only)

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.

3.2 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and the contract drawings.

**END OF SECTION**

**SECTION 265113**

**INTERIOR LIGHTING**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the equipment indicated in the Contract Documents with supplementary items necessary for a proper and functioning installation.

B. Section Includes:
   1. Interior luminaires
   2. Exit signs

1.2 REFERENCES

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

B. Refer to Division 26 Section “Low Voltage Electrical Power Conductors and Cables” for wiring requirements

C. Refer to Division 26 Section “Emergency Lighting” for emergency lighting units, exit signs with battery backup and lighting inverter systems.

D. Refer to Division 26 Section “Site Lighting” for site luminaires and poles.

1.3 SUBMITTALS

A. Product data:
   1. For each luminaire type, submit a technical cut sheet with complete model number(s) and included options clearly noted, plus luminaire support points, weight, accessory information and photometric performance data indicating total luminaire efficiency. Place luminaire type (e.g. ‘F1’) at the top of each cut sheet page for that luminaire.
   2. Submit a technical cut sheet for the associated driver proposed for that luminaire. When multiple luminaires use the same driver, a single cut sheet for the driver may be submitted with all luminaires utilizing that driver clearly labeled on the cut sheet.

B. Finish samples: For decorative luminaires, submit paint/finish samples to Architect via mail for review and selection.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit under requirements and format listed in Division 26 Section "Common Work Results".

B. Include the following documentation
   1. All required submittals for this section, updated to reflect required changes from review comments.
   2. Warranty letter(s) indicating dates of coverage and warranty claim contact information.

1.5 QUALITY ASSURANCE

A. Electrical components 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. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

1.6 DEFINITIONS

A. CRI: Color rendering index

B. CCT: Correlated color temperature

C. BUG: Backlight, Uplight and Glare ratings for luminaires based on IESNA TM-15-07.

1.7 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported from structure, including HVAC equipment, fire-suppression system, and partition assemblies.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver luminaires in factory-fabricated packaging.

B. Handle lighting fixtures carefully to prevent breakage, denting and scoring the fixture finish. Do not install damaged lighting fixtures.

C. Store product in a clean, dry space protected from weather.

1.9 WARRANTY

A. All equipment shall be warranted to be free of defects in materials and workmanship by the manufacturer for the time period listed below from the date of project substantial completion:

1. LED luminaires (including LED power supply): Five (5) years

1.10 EXTRA MATERIAL

A. Special Tools - Two (2) tools to remove and install each type and size of fasteners on fixtures equipped with vandal resistant fasteners.

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES

A. Refer to the Luminaire Schedule on the drawings for types of luminaires (e.g. F1, F2, EM1, etc.). The luminaire type listed in the schedule will appear on the lighting plans adjacent to the symbol for each luminaire.

B. For each luminaire type the manufacturer and model listed first in the schedule, in conjunction with all other luminaire attributes listed on the schedule, shall be considered the basis of design. The remaining acceptable manufacturers shall meet or exceed the performance of the basis of design. When a discrepancy exists between the model number and the other attributes listed for that luminaire, the Contractor shall ask for clarification during the bidding process or include the more expensive option as part of their bid.

C. Provided luminaire doors with rubber, fiberglass gaskets or equivalent material to prevent light leak. Luminaires shall be provided with proper thermal protection as required for surrounding environment.

D. Acrylic lenses shall be prismatic and not less than 0.125-inches thick nominal, unless noted otherwise on plans.

E. All luminaire finishes shall be factory applied unless specifically noted otherwise. Refer to schedule on drawings for finish color.

2.2 SOLID STATE LUMINAIRES

A. Photometric Measurement: Comply with IESNA LM-80-21.

B. Lumen Maintenance: Tested in accordance to IESNA LM-79-19.

C. Long Term Lumen Maintenance: Comply with IESNA TM-21-11.

D. The basis of design for each LED luminaire is listed on the Luminaire Schedule. All other listed acceptable manufacturers shall meet or exceed the delivered lumens of the basis of design using +/- 10% input watts.

E. CRI and CCT per Luminaire Schedule on plans

2.3 EXIT SIGNS

A. Mounting type and chevrons shall be as indicated on the Drawings. Lettering and chevron-type directional indicators shall comply with NFPA 101, Life Safety Code, and shall be Listed in accordance with UL 924, Standard for Safety Emergency Lighting and Power Equipment.

B. Sign housing type shall be as indicated on the Luminaire Schedule.

C. Mounting canopies will be of identical construction and color to match the exit frame.

2.4 LED POWER SUPPLIES

A. Acceptable manufacturers: Selected and tested by luminaire manufacturer with specified luminaire for compatibility and performance.

B. Provide with 0-10 VDC dimming interface when specified on Luminaire Schedule on plans.

C. LED power supplies shall have temperature and a moisture rating suitable for the environments for which it is to be installed. Luminaires installed in low ambient temperature areas shall have power supplies specifically designed for low temperature operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install luminaires at locations and heights as indicated, in accordance with luminaire manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation", NEMA Standards and with recognized industry practices to ensure that luminaires fulfill requirements.

B. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

C. Check the building electrical system requirements and architectural finishes. Regardless of the catalog number prefixes and suffixes shown, furnish fixtures with the proper trim, frames, supports, hangers, driver, voltage rating, and other miscellaneous appurtenances to properly coordinate with Project conditions. Verify with Engineer prior to ordering.

D. Check the type of ceilings to be installed in each room and verify that the recessed light fixtures are proper for the type of ceiling to be installed before ordering fixtures. Provide a frame compatible with the type of ceiling in which the recessed lighting fixture is installed. Refer to the Architectural Room Finish Schedule for the specified ceiling type.

E. Install suspended luminaires and exit signs using pendants supported from swivel hangers. Heavy duty jack chain supports may be used where indicated on the fixture schedule. Provide pendant or chain length required to suspend luminaire at indicated height.

F. Support luminaires larger than 2 x 4 foot size independent of ceiling framing using #12 steel wires anchored to structure.

G. Locate ceiling luminaires as indicated on the architectural reflected ceiling plan.

H. Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prohibit movement.

I. Finishing Collar or Combination Finishing Collar/Outlet Box (Surface Mounted Fixture Used With Exposed Raceway):
   1. Provide finishing collar where surface mounted fixture is installed on an exposed raceway outlet box and the fixture base is larger than the outlet box.
   2. Provide combination finishing collar/outlet box where surface mounted fixture is not indicated to be installed on an exposed raceway outlet box, but raceway cannot be run directly into fixture body due to fixture design.

J. The Contractor shall install fixture supports as required. Fixture installations with fixtures supported only by insecure boxes will be rejected. It shall be the Contractor's responsibility to support all lighting fixtures adequately, providing extra steel work for the support of fixtures if required. Any components necessary for mounting fixtures shall be provided by the Contractor. No plastic, composition or wood type anchors shall be used.

K. Exposed Grid Ceilings: Support surface mounted luminaires on grid ceiling directly from building structure Provide auxiliary members spanning ceiling Ts to support surface mounted luminaires Fasten surface mounted luminaires to ceiling T using bolts, screws, rivets, or suitable clips. Provide independent support for all fixtures over 50 lbs.

L. Install recessed luminaires to permit removal from below.

M. Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.

N. Install wall mounted luminaires at height as scheduled.

O. Install accessories furnished with each luminaire.

P. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.

Q. Bond fixtures and metal accessories to branch circuit equipment grounding conductor.

R. Highbay Luminaires: Use power hook hangers rated 500 pounds minimum or provide safety chain between housing and structure. Provide safety chain between reflector and housing.

S. Protect installed fixtures from damage during the remainder of the construction period.

3.2 ADJUSTING AND CLEANING

A. Align luminaires and clean lenses and diffusers at completion of Work. Clean paint splatters, dirt, and debris from installed luminaires.

B. Aim and adjust luminaires as indicated on Drawings or as directed by the Architect/Engineer.

C. Touch up luminaire finish at completion of work.

3.3 FIXTURE CONNECTIONS

A. Direct box or conduit connections for surface and recessed fixtures. Flexible metal conduit from a J-box for recessed lay-in light fixtures. Flexible metal conduit shall be minimum 3/8" diameter and six foot maximum length. Conduit length shall allow movement of the fixture for maintenance purposes.

B. The flexible connectors shall be all steel, galvanized, clamp type with locknut or snap-in connector including those used on the master-slave unit.

C. Fixture whips shall be supported to prevent them from lying on or being supported by the ceiling grid. Supports shall be listed for raceway support. Tape and other temporary means are not acceptable.

3.4 FIELD QUALITY CONTROL

A. Upon completion of installation of interior lighting fixtures, and after circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at the Project Site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

**END OF SECTION**

**SECTION 265200**

**EMERGENCY LIGHTING-UNIT EQUIPMENT**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following emergency lighting-unit equipment indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment included in this Section
   1. Emergency lighting units
   2. Exit signs

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

1.3 SUBMITTALS

A. Include outline drawings, lamp and ballast data, battery/charger information, support points, weights, accessory information and performance data for each luminaire type.

B. For each luminaire type, submit luminaire information in the following example table format, and submit catalog cuts with highlighted catalog numbers and required accessories.

| LUMINAIRE | | BALLAST | LAMP | ANSI INPUT WATTS |
|---|---|---|---|---|
| Type | Manufacturer and Catalog No. | Manufacturer, Quantity per Fixture, and Catalog No. | Manufacturer, Quantity per Fixture, and Catalog No. | |

1.4 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver lighting fixtures individually wrapped in factory-fabricated fiberboard type containers.

B. Handle lighting fixtures carefully to prevent breakage, denting and scoring the fixture finish. Do not install damaged lighting fixtures.

C. Store product in a clean, dry space protected from weather.

PART 2 - PRODUCTS

2.1 EXIT/EMERGENCY LIGHTING AND ACCESSORIES

A. See the Luminaire Schedule on the drawings, for type of fixtures and catalog numbers. Catalog numbers are shown on the drawings for quality and performance requirements only. Fixtures manufactured by others are equally acceptable provided they meet or exceed the performance of the indicated fixtures, and meet the intent of the design.

B. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 SELF-POWERED EXIT SIGNS

A. Acceptable Manufacturers: As indicated on the Drawings.

B. Exit light mounting type shall be as indicated on the Drawings.

C. Housing material shall be as indicated on the Drawings.

D. Lettering and chevron-type directional indicators shall comply with NFPA 101, Life Safety Code, and shall be Listed in accordance with UL 924, Standard for Safety Emergency Lighting and Power Equipment.

E. Exit sign design will allow universal 120/277VAC, 60 Hz operation.

F. Normal illumination will be provided by LED’s. Normal LED lamp life shall be in excess of 20 years.

G. Mounting canopies will be of identical construction and color to match the exit frame.

H. Provide with a fully automatic emergency operation module. All emergency module components shall mount inside the exit sign housing and will include a solid-state, constant current type battery charger; a maintenance-free, nickel-cadmium battery; an AC-On indicator light; and a test switch.

I. Standard operating temperature: 68°F to 86°F. Provide exit sign suitable for environmental conditions above or below the standard operation temperature or as noted in the Luminaire Schedule.

J. Provide unit with self-testing/self-diagnostic electronics where noted on the Drawings.

K. Provide wire guard where noted on the Drawings.

## 2.3 EMERGENCY LIGHTING UNITS

A. Acceptable Manufacturers: As indicated on the Drawings.

B. Emergency light mounting shall be as indicated on the Drawings.

C. Housing material shall be as indicated on the Drawings.

D. Units shall comply with NFPA 101, Life Safety Code, and shall be Listed in accordance with UL 924, Standard for Safety Emergency Lighting and Power Equipment.

E. Emergency operation shall be provided for a minimum of ninety (90) minutes.

F. Design will allow universal 120/277VAC, 60 Hz operation.

G. Lamp type, quantity, and wattage shall be as indicted on the Drawings.

H. Emergency components shall include a solid-state, constant current type battery charger; a maintenance-free, nickel-cadmium battery; an AC-On indicator light; and a test switch.

I. Standard operating temperature: 68°F to 86°F. Provide emergency light suitable for environmental conditions above or below the standard operation temperature or as noted in the Luminaire Schedule.

J. Provide unit with self-testing/self-diagnostic electronics where noted on the Drawings. Self-testing feature shall comply with the requirements of NFPA 101 and the NEC.

K. Provide wire guard where noted on the Drawings.

## 2.4 REMOTE LIGHTING HEADS

A. Acceptable Manufacturers: As indicated on the Drawings.

B. Remote head mounting shall be as indicated on the Drawings.

C. Housing material shall be as indicated on the Drawings.

D. Lamp type, quantity, voltage, and wattage shall be as indicted on the Drawings.

E. Units shall comply with NFPA 101, Life Safety Code, and shall be Listed in accordance with UL 924, Standard for Safety Emergency Lighting and Power Equipment.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

C. Check the building electrical system requirements and architectural finishes. Regardless of the catalog number prefixes and suffixes shown, furnish fixtures with the proper trim, frames, supports, hangers, ballasts, voltage rating, and other miscellaneous appurtenances to properly coordinate with Project conditions. Verify with Engineer prior to ordering.

D. Check the type of ceilings to be installed in each room and verify that the recessed light fixtures are proper for the type of ceiling to be installed before ordering fixtures. Provide a frame compatible with the type of ceiling in which the recessed lighting fixture is installed. Refer to the Architectural Room Finish Schedule for the specified ceiling type.

E. Install suspended luminaires using pendants supported from swivel hangers. Chain or cable supports may be used in unfinished spaces or where indicated on the fixture schedule. Provide pendant, chain, or cable length required to suspend luminaire at indicated height.

F. Fixture whips shall be supported to prevent them from lying on or being supported by the ceiling grid. Supports shall be listed for raceway support. Tape and other temporary means are not acceptable.

G. Locate exit and emergency luminaires as indicated on the Drawings. Install accessories furnished with each luminaire.

H. Install surface mounted luminaires plumb and adjust to align with building lines and with each other. Secure to prohibit movement.

I. Finishing Collar or Combination Finishing Collar/Outlet Box (Surface Mounted Fixture Used With Exposed Raceway):
   1. Provide finishing collar where surface mounted fixture is installed on an exposed raceway outlet box and the fixture base is larger than the outlet box.
   2. Provide combination finishing collar/outlet box where surface mounted fixture is not indicated to be installed on an exposed raceway outlet box, but raceway cannot be run directly into fixture body due to fixture design.

J. The Contractor shall install fixture supports as required. Fixture installations with fixtures supported only by insecure boxes will be rejected. It shall be the Contractor's responsibility to support all lighting fixtures adequately, providing extra steel work for the support of fixtures if

required. Any components necessary for mounting fixtures shall be provided by the Contractor. No plastic, composition or wood type anchors shall be used.

K. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.

L. Bond fixtures and metal accessories to branch circuit equipment grounding conductor.

M. Protect installed fixtures from damage during the remainder of the construction period.

N. Insert a copy of the battery warranty in each unit and mark on batteries the date placed in service.

O. Emergency Lighting Units
   1. Units shall be mounted so that they may easily be removed for service.
   2. Units shall be permanently connected to a 120/277 volt power source in compliance with the NEC.
   3. Remote lamps shall be connected to battery unit using raceway and wire size noted on the Drawings.

## 3.2 ADJUSTING AND CLEANING

A. Align luminaires and clean lenses and diffusers at completion of Work. Clean paint splatters, dirt, and debris from installed luminaires.

B. Aim and adjust luminaires as indicated on Drawings or as directed by the Architect/Engineer.

C. Touch up luminaire finish at completion of work.

## 3.3 FIELD QUALITY CONTROL

A. Upon completion of installation of interior lighting fixtures, and after circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at the Project Site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

**END OF SECTION**

**SECTION 265629**

**SITE LIGHTING**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install site lighting indicated by the Contract Documents with supplementary items necessary for proper installation.

B. Equipment included in this Section
   1. Exterior luminaires and accessories
   2. Poles
   3. Foundations (refer to structural drawings pole foundation design and reinforcing requirements)

1.2 REFERENCES

A. Applicable provisions of Division 1 govern work under this Section.

1.3 SUBMITTALS

A. Shop Drawings: Indicate dimensions and components for each luminaire, pole and base.

B. Product Data: Provide dimensions, ratings, performance data, lamp and ballast data, weights and accessory information for each type.

C. Manufacturer's Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency specified under "Regulatory Requirements".
   2. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

D. Light Layout: Provide a computer generated factory point to point foot-candle layout of the project for each area involved.

E. Design Data: Include lighting calculations.

1.4 PROJECT RECORD DOCUMENTS

A. Accurately record actual locations of each luminaire, pole and underground circuit.

1.5 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.6 COORDINATION

A. Use bolt templates and pole mounting accessories to install anchor bolts in pole base.

1.7 WARRANTY

A. All equipment shall be warranted to be free of defects in materials and workmanship by the manufacturer for the time period listed below from the date of project substantial completion:
   1. LED luminaires (including LED power supply): Five (5) years
   2. Pole (including pole finish): Five (5) years Ten (10) years

PART 2 - PRODUCTS

2.1 LUMINAIRES

A. Furnish products as specified in schedule on Drawings.

2.2 FUSES

A. Furnish and install a fuse holder and fuse in each ungrounded leg of the electrical circuit supplying the outdoor luminaire. Every luminaire shall be separately fused with a waterproof fuse holder. Size the fuse for the amperage of the luminaire. Tap the circuit conductors with a minimum #10 AWG conductor to serve the luminaire. The fuse and holder shall be accessible through the handhole. Provide sufficient wire to bring fuse holder outside of handhole.

2.3 POLES

A. Furnish products as specified in schedule on Drawings.

B. Handhole: With removable weatherproof cover.

C. Anchor Bolts: As recommended by pole manufacturer. Provide template, flat washers, lock washers, and hex nuts for each pole.

2.4 POLE FOUNDATIONS

A. Construct from reinforced concrete in sizes as shown on structural drawings and to meet the minimum structural requirements of the site soil conditions.

B. Provide 3/4" X 10'0" ground rod in the pole foundation so that the ground rod projects 3" up into center of pole base.

C. The exposed surface area of the foundation shall have the forms removed and the concrete rubbed out to a smooth finish.

D. Paint pole base with yellow traffic marking paint where installed in parking lots subject to contact with vehicles.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install in accordance with manufacturers' instructions.

B. Minimum underground conduit size is 1 inch.

C. Underground and exterior wire shall be type XHHW-2.

D. Project anchor bolts 2 inches minimum above base.

E. Install all anchor bolts and handhole fasteners with anti-seize compound.

F. Install poles plumb. Provide shims or double nuts to adjust plumb.

G. Use belt slings or non-chafing ropes to raise and set pre-finished luminaire poles.

H. Bond each luminaire, each metal accessory, the ground rod and the pole to the branch circuit equipment ground conductor with a separate ground wire sized per NEC or as shown on the drawings.

### 3.2 FIELD QUALITY CONTROL

A. Operate each luminaire after installation and connection. Inspect for improper connections and operation.

### 3.3 ADJUSTING

A. Aim and adjust luminaires as indicated on Drawings or as directed by the A/E.

B. All new lamps shall be operational at the Substantial Completion of the project.

### 3.4 CLEANING

A. Clean photometric control surfaces.

B. Clean finishes and touch up damage.

**END OF SECTION**

**SECTION 271100**

**COMMUNICATIONS EQUIPMENT ROOM FITTINGS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the required remote control and signal cabling indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references.

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

D. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them. See Sections 270513.

1.3 SUBMITTALS

A. See Section 270513.

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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

C. Grounding: Comply with ANSI-J-STD-607-A.

D. Hole spacing and mechanical dimensions: Comply with EIA-310.

1.5 TELECOMMUNICATION ROOMS

A. The Telecommunications Room is generally considered to be a floor serving facility. The horizontal cross-connect links the horizontal subsystem and the backbone subsystem together.

B. The Telecommunications Rooms shall have a minimum dimension of 10’ x 10’ square.

C. L-shaped or other shaped dimensions are not acceptable.

D. Concrete columns in this area are not acceptable.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer’s published recommendations.

C. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather tight, wet work in spaces is complete and dry, and work above ceilings is complete.

3.2 CABLE TRAYS

A. Ladder Racks: Inside the Equipment room and Telecommunications rooms, ladder rack is to be used for horizontal wire management. This tray is designated for cabling to remain within these rooms. Any implementation of this ladder rack equipment will include spill brackets at all inside corners.

B. Cable Tray
1. The cable tray will be installed parallel to the furred out wall 6 to 12 inches inside the Telecommunications/Equipment rooms. The cable tray will continue into far enough to deliver the riser, station, horizontal, and fiber to the end destination. Cascade transitions

(waterfalls) shall be used if height variations occur between the cable tray equipment and the ladder rack equipment.

2. All cable trays inside the Telecommunications/Equipment rooms must be a prefabricated structure consisting of two (2) side rails connected by individual transverse members. Wire mesh type or Mono Mount wire cable tray systems will not be used. The horizontal cable tray system shall be able to support a minimum of 100 lbs of cable per linear foot.

C. Drop-off support for the copper cable going into the frames/racks shall be used.

## 3.3 OUTLET BOXES

A. Outlet boxes shall be assembled as follows
   1. Depth: 3.26 inches
   2. Height: 4.16 inches
   3. Width: 3.51 inches

## 3.4 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated (both sides), ¾ by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06.

B. Plywood should be installed 1 foot above finished floor.

## 3.5 EQUIPMENT FRAMES

A. All equipment frames will be placed with their associated vertical and horizontal wire management.

B. A standard equipment frame foot print, including installed equipment is 26 inch x 8 ft. The 8 ft measurement is from any obstruction or wall.

## 3.6 LIGHTNING PROTECTION

A. Contractor shall provide multi-pair protector panel(s), including mounting and termination hardware. The multi-pair protector panel(s) shall be UL listed.

B. For small pair count applications (less than or equal to 200-pairs), the multi-pair protector panel shall consist of a mounting panel for a series of solid-state protector units, 710-type connector for input, and 110-type termination blocks for output. Insertion of the protector units into the mounting panel will complete the circuit. The multi-pair protector panel(s) shall be available in 25-, 50-, 100-, and 200-pair counts.

C. Solid State Protection Units:
   1. Over Voltage DC Breakdown Voltage: 75V-480V.
   2. DC Holdover Current: Clears within 20ML.
   3. Capacitance: Less than <200 pF.

4. Rated Impulse Capability: Unlimited @100A safety: Fail safe mechanism fast acting balanced.

## 3.7 DEMARCATION REQUIREMENTS

A. Contractor shall coordinate with owner's selected service provider all requirements for the demarcation point.

B. In the event that the service provider's requirements differ from the work shown on the documents, the contractor shall not proceed on the installation without a document from the engineer.

## 3.8 COMMUNICATION SYSTEM GROUNDING

A. Refer to Specification Section 260526.

## 3.9 TELECOMMUNICATIONS ROOM

A. The telecommunication room shall house racks, voice termination fields and required cable routing hardware. If one mounting rail of the rack is placed against a wall, the mounting rail shall be no closer than 6" to the wall to allow room for vertical management. Where there is more than one (1) rack, the racks shall be ganged with vertical management hardware. Ganged rack frames will be placed in a manner that will allow a minimum of three (3) feet of clearance from the front and rear mounting surfaces and on one side of the ganged assembly. Open frame equipment racks shall be bolted to the floor by means of the manufacturer's recommended fasteners. Cable guides shall be bolted or screwed to racks. Racks shall be installed level. Ganged racks shall be bolted together. Ganged rack cabinets shall have adjacent side panels removed.

B. Voice termination fields shall be mounted on 4' x 8' x 3/4" virgin fire retardant plywood, unless otherwise noted in drawings. There shall be minimum of three (3) conduits of a minimum of 4" in diameter in telecommunications rooms as required. Conduits for data backbone shall be located adjacent to the racks and conduits for voice shall be located adjacent to the voice termination fields. The contractor shall provide innerduct for all backbone fiber runs. Contractor shall provide required ladder and wall mount management rings to properly support and dress cables from conduits to racks and frames.

C. System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with TIA/EIA 606. Penetrations in fire-rated construction shall be firestopped. Conduits, outlets and raceways shall be installed in accordance with Division 26. Wiring shall be installed in accordance with EIA/TIA 569A. Wiring, and terminal blocks and outlets shall be marked in accordance with TIA/EIA 606. Cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with ac power cables. Cables not installed in conduit or wireways shall be

properly secured and neat in appearance and, if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.

**END OF SECTION**

**SECTION 274100**

**AUDIO VIDEO SYSTEMS**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the required AV equipment and cabling indicated by the Contract Documents with supplementary items necessary for proper installation. Contractor provides a $150,000 allowance for a Bright sign Bus Transportation turnkey system for item #2. System consists of numerous monitors for gate location and schedules on site. System to include TV's /mounts, hardware, programming, and installation.

B. Types of AV systems included in this Section
   1. Offices - Qty: 21
   2. Exterior Digital Signage System – Qty:4 75" TV's and 36 24" TV's

C. Work included in other Sections
   1. Empty conduit, junction boxes, wall boxes, ceiling boxes, floor boxes, fittings, etc. These items will be provided and installed by the Electrical Contractor.
   2. Power and power wiring to all A/V equipment. This will be provided and installed by the Electrical Contractor.
   3. Refer to the plans for a Responsibility Matrix for division of work.

1.2 CONTRACTOR'S RESPONSIBILITY

A. Thoroughly review the Contract Drawings and Specifications with regard to the work specified in this Section to insure its completeness. If there are questions or if the AV Contractor notes any discrepancies in the contract documents, notify the Engineer in writing a minimum of five (5) days prior to bid submission.

B. The AV Contractor shall visit the site prior to submitting a bid. If there are any existing conditions that will prevent or impede the work as specified, notify the Engineer in writing a minimum of five (5) days prior to bid submission.

C. Field verify all dimensions affecting the work. The AV Contractor will be responsible for any dimensional variances between the contract documents and actual field conditions.

D. Coordinate all work with other trades to avoid project delays.

1.3 SHOP DRAWINGS

A. Shop Drawings shall be submitted to the Engineer for approval in accordance with the requirements of the Contract Documents.

B. Provide the following before installation of any equipment.
   1. Functional schematics of each system
   2. Mounting methods
   3. Detailed dimensioned drawings for all custom fabricated material
   4. Details of any deviations from Contract Documents
   5. Manufacturer's specification sheets
   6. Lists of equipment for approval
   7. Dimensioned plans showing locations of all equipment provided by the AV Contractor.
   8. Contractor to provide touch panel Graphical User Interface design for the Engineer and Owner's approval. If Owner has panel design standards, Contractor shall coordinate to implement into final product.

## 1.4 QUALITY ASSURANCE

A. Offers will be considered only from a Contractor who has at least five (5) years of experience in the furnishing and installation of similar Systems; the contractor shall submit names of three (3) similar sized projects installed by him within the past five (5) years. The Contractor shall be an authorized dealer of all major equipment components supplied. In addition, the Contractor must employ competent electronics technicians to fabricate, install and test such equipment in a manner that clearly indicates that the technicians are knowledgeable in the complexities of the A/V systems.

B. The Contractor shall supply to the Owner certification that the satisfactory operation of installed systems shall be guaranteed and warranted for a period of one (1) year from date of final acceptance by the Owner. The warranty includes all replacement parts, adjustments and service required to ensure continually satisfactory performance of all the Systems.

C. Substitutions: The AV Contractor will obtain approval for alternative equipment and materials in writing from the engineer a minimum of ten (10) days prior to the bid date.

D. Approved Installers
   1. NVision Source Technologies, Gulfport, Mississippi. Phone: 228-383-0497
   2. Sands Tech AV, Pensacola, Florida. Phone: 850-361-2194
   3. ProAV, 8812 Grow Drive, Pensacola, Florida. Phone: 850-667-8000
   4. Sweetwater Integration, 8006 Beverly Pkwy, Pensacola, Florida. Phone: 800-925-9822
   5. Or an approved equal to

E. After substantial completion of the specified systems and before final acceptance of these systems by the Owner or his representative, the Contractor shall furnish the Owner the following:
   1. Systems operation manuals, equipment operation manuals, maintenance data, descriptive literature and other information that is pertinent to the operation and performance of the Systems.
   2. Manufacturer's guarantees and warranties and Contractor's guarantee as previously called for in Paragraph 1.4 – B.
   3. Point-to-point wiring diagrams showing interconnection of all equipment.

4. Complete functional schematics describing the inter-relationship of all active and passive components.

## 1.5 BID SUBMITTAL

A. Bids submitted by Contractor must be in complete compliance with the terms and requirements of the Specification describing the equipment, functions, and performance. Any exceptions to, omissions from, and modifications to the Specification, that are contained in the Bid Submittal, will be considered unacceptable to the Owner.

B. Pricing shall be all-inclusive for a turn-key, fully functional A/V system. Pricing shall include all costs, including but not limited to: material, labor (including installation and programming), travel expenses, taxes, warranties, licensing fees, etc.

C. Contractor shall provide as a separate attachment an annual service agreement proposal that would take effect after the initial warranty period. Provide terms and conditions, including labor rates and service level options.

## 1.6 FUNCTIONAL REQUIREMENTS

1. Offices Presentation (Qyt:7 65” TV’s and 14 75” TVs)
    a. General Requirements: The A/V system for the offices and conference presentation room will consist of the following items:
        1) Seven (7) 65” TV’s (65” TV) with wall TV mount. Refer to drawings for mounting of TV.
        2) Fourteen (14) 75” TV’s (75” TV) with wall TV mount. Refer to drawings for mounting of TV.
        3) HDMI cable from behind the TV to a HDMI faceplate at 18” A.F.F.
        4) Refer to drawings for location.
2. Exterior Digital Signage System
    a. General Requirements: The A/V system for the offices and conference presentation room will consist of the following items:
        1) Four (4) 75” TV’s (75” TV) with wall TV mount. Refer to drawings for mounting of TV for the Transit Center.
        2) Thirty-six (36) 24” TV’s (24” TV) with ceiling mounted bracket. Refer to drawings for mounting of TV for the Transit Center.
        3) Four (4) Digital media player per TV for the 75” TV’s Transit Center.
        4) Eighteen (18) Digital media player dual output for 24” TV’s
        5) Content Management System - Optisign License per year. Or an approved equal to.
        6) HDMI -3’ cable player to display.
        7) CAT6 cable from behind the TV to the nearest IDF room. Cabling provided and installed by owner’s integrator.
        8) Twenty-two (22) 128GB Industrial micro-SD Cards
        9) Brightsign Control Plus Subscription
        10) Centralize Content Management
        11) Refer to drawings for location.

b. System Operation:
   1) Basic Operation: This system will be controlled via a PC that the transit office. PC will update all content at bus numbering and routing schedule monitors. The system to include player provisioning, CMS setup, template creation, departure board formatting, route displays, advertising playlist, emergency messaging integration, user training and acceptance testing.

PART 2 - PRODUCTS

2.1 MATERIALS

B. Equipment Selection: Equipment covered by these Specifications is identified by manufacturer and model number. The performance data and part number provided herein are for the purpose of establishing equality of performance and function of equipment and are not intended to be restrictive. However, equipment bid as an alternate or equal shall have laboratory-measured data equal to that of the specified equipment in terms of quality, performance, and function. The Owner shall determine the acceptability of proposed substitutions.

C. Equipment Lists: The following sections describe the functions and requirements applicable to each of the designated Systems. These are submitted to express the purpose, operation, and satisfactory performance of the system. The components, material and workmanship required to achieve these functions, while not explicitly stated in this Section, are, nonetheless, implied and shall be furnished and installed by the Contractor. Where more than one (1) man/model number is listed, the features and functions of the first listed is representative of the component requirements. Equipment quantities shall be determined by the Contractor from the drawings and jobsite conditions.
   1. MPWP-1 (Media Presentation Wall Plate):
      1) The electrical contractor will provide suitable pathways from the floor box to the televisions.
      2) Offices and Conference Rooms HDMI between TV and HDMI input
      3) HDMI Cables – (No plan Mark)
      4) Less than 9 feet – Snap AV B4HD Series
      5) More than 9 feet – Snap AV B4HD 7.5
   2. 65” TV (LED Video Monitors)
      a. LG65QNED84BUA – 65” Television (Basis of Design)
         1) Chief AS3LD-Wall Mount
         2) Or approved equal to.
         3) Provided/installed by A/V contractor.
   3. 75” TV (LED Video Monitors)
      a. LG75 QNED84BUA – 75” Television (Basis of Design)
         1) Chief AS3LD-Wall Mount
         2) Or approved equal to.
         3) Provided/installed by A/V contractor.
   4. 24” TV (LED Video Monitors) Outdoor Type Transit Center
      a. Samsung OH24B – 24” Television (Basis of Design)

1) Peerles pole-mount with extension and back-to-back mount -PLB-1
2) TV Enclosure – Armagard PDS-24-W-L
3) Or approved equal to.
4) Provided/installed by A/V contractor.

5. 75” TV (Outdoor Type)
   a. Furrion 75” FDUP50CSA
   b. Chief AS3LD -Wall mount
   c. TV Enclosure – Armagard PDS-75-W-L
   d. Or approved equal to.
   e. Provided/installed by A/V contractor.
6. Digital Media Player and CMS Optisigns Licensing (per year)
   a. Bright Sign -HD225 for single TV locations
   b. Bright Sign- XT2145 Player for dual TV locations
   c.
   d. Or approved equal to
7. AV Switches Contractor to size accordingly
   a. Netgear
      1) GSM4230up
      2) Cisco
      3) Or approved equal to.

D. Cables and Connectors – West Penn, Windy City, Belden, Liberty or an approved equal to
   1. Panduit CAT6 UTP (Black) To be provided and installed by owner’s cabling contractor.

## PART 3 - EXECUTION

### 3.1 EQUIPMENT SELECTION

A. All equipment components supplied shall be current models, not obsolete or discontinued models. All equipment components, except as herein called for, shall be new, not used, nor re-manufactured except for equipment provided by Owner.

B. If alternate manufacturers are proposed, provide itemized list of proposed substitutions, including cut sheets, specifications, and other material necessary for approval as an equal product.

### 3.2 WORKMANSHIP

A. All equipment and associated hardware shall be fabricated and installed in accordance with the manufacturer’s specific recommendations and in a manner that is consistent with practices and standards generally accepted by the professional audio and video industry. All wiring, connections and necessary termination identifications shall be accomplished expertly within the rack cabinet. Tag all cables and terminal strips.

B. Location of grounding points shall be determined carefully to ensure minimization of system hum and elimination of ground loops. In addition, all connections of shields and conductors to equipment shall be in accordance with manufacturer's instructions.

## 3.3 PROOF OF PERFORMANCE REQUIREMENTS

A. This section is to be performed by the A/V system Contractor.

B. The satisfactory performance of the A/V systems shall be determined by specific tests and adjustments after substantial completion of the installation has been accomplished. The systems shall meet the following requirements, based upon available data and manufacturer's published Specifications.
   1. All video sources shall be verified for proper operations and all field adjustments to this equipment have been performed.
   2. Provide technical support during system tuning and adjustment phases.

## 3.4 PROGRAMMING

A. The audio-visual integrator shall provide all programming passwords to the owner at the time when owner manuals are turned over to the Owner. The Owner shall be able in the future make any changes to the system at their discretion and not be forced to use a specific installer based on the system architecture. Provide Code "Compiled/Uncompiled" to the Owner for future changes.

## 3.5 TRAINING

A. Contractor shall provide and coordinate detailed training on each type of A/V system. Provide hands-on training and cheat sheet of how to use the system.

**END OF SECTION**

**SECTION 274133**

**MASTER ANTENNA TELEVISION SYSTEM**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide and install the following Master Antenna Television System indicated by the Contract Documents with supplementary items necessary for proper installation.

1.2 REFERENCES

A. See Section 270513, COMMON WORK RESULTS FOR COMMUNICATIONS.

1.3 SYSTEM DESCRIPTION

A. General: The system shall provide adjacent channel operation of 35 TV channels.

B. Headend: Install and interface the headend equipment according to the manufacturer's headend schematic diagram for adjacent TV channel operation. The system shall receive the specified off air Very High Frequency (VHF) and Ultra High Frequency (UHF) TV channel signals, convert the UHF channels to vacant Community Antenna Television (CATV) channels and process and distribute the signal to all locations indicated.
   1. In the event that a selected VHF TV channel's transmitter site is within 10 miles of the project location, convert that to a vacant CATV channel to minimize interference.
   2. Provide a 32 db directional coupler in the headend equipment rack as a test port for accessing each TV channel without the need to disconnect distribution cables or equipment.
   3. Each TV channel shall be processed as a single channel.

C. Cabling: The system shall include, but not be limited to, TV antennas, antenna tower, antenna masts, headend cabinet, broadband TV headend amplifier, necessary combiners, traps and filters, distribution amplifiers, cable and connectors, and necessary passive devices such as splitters, directional couplers, television (TV) outlets, and multi-taps.
   1. They system shall provide for connection of a standard CATV cable ready TV receiver to the designated TV outlets in day rooms, waiting rooms, recreation rooms, and other non-patient areas as shown on the drawings.
   2. System layout that loops the RF cable from room to room is not acceptable. Each floor or ward distribution system shall be a "tap" design where each room's TV outlet is fed from a directional multi-tap provided from a centrally located (usually in the corridor) lateral trunkline cable. Each ward or floor lateral trunkline cable shall be connected to a vertical trunkline riser cable in the associated signal closet. Each vertical riser trunkline

cable shall be connected to the headend output. Distribution (floor or riser) amplifiers shall be provided to satisfy system's TV outlet signal level requirements.

## 1.4 PERFORMANCE REQUIREMENTS

A. On-Site TV Signal Survey:
   1. Conduct an onsite TV signal survey. The survey shall be accomplished by using a signal level meter (visual signal level or spectrum analyzer are acceptable alternates) and a given single channel TV antenna. A computer-generated signal survey obtained from the TV equipment manufacturer is an acceptable alternate to the on-site survey.
   2. The longitude, latitude, and elevation above mean sea level may be obtained from the Resident Engineer.

B. When the Project is located within the Grade A and B contours of the specified TV channels, the signal quality at each TV outlet shall not be less than Television Allocation Standards Organization (TASO) Grade EXCELLENT (45 dB Signal-to-Noise [S/N] ratio).

C. When the VAMC is located outside the Grade A and B contours of the specified TV channels, the signal quality at each TV outlet shall not be less than TASO. Grade FINE (36 dB S/N ratio).

D. The signal level of each channel at each TV outlet shall be $\pm$ 10 dBmV, plus or minus 5 dB across 75 Ohms. NHCU: The signal level at the Power Distribution Room TV outlet shall be $\pm$ 25 dBmV, plus or minus 2 dB across 75 Ohms.

E. The system shall meet the following minimum parameters at each TV outlet.
   1. Cross Modulation: -46 dB
   2. Hum Modulation: -55 dB
   3. Return Loss: -14 dB
   4. Isolation (outlet-outlet): 24 dB
   5. Visual to Aural Carrier Ratio: 13 dB to 17 dB below visual
   6. Impedance: 75 ohms

## 1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications
   1. The manufacturer shall have had experience with three (3) or more installations of systems of comparable size and complexity as regards coordinating, engineering, testing and supervising. Each of these installations shall have been in successful operation for one (1) or more years.
   2. Prior to review of submittals, Owner reserves the right to:
      a. Have the manufacturer submit a list of locations of similar installations.
      b. Inspect any of these installations and question the user concerning the installations without the presence of the supplier.

B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this project.

1. Testing Personnel: An employee of the installer, certified by National Institute for Certification in Engineering Technologies (NICET) as Video Security Systems Level III technician.

C. Standards and Testing: Supplies, materials or equipment shall be listed, labeled, or certified by a nationally recognized testing laboratory to comply with referenced UL Standards.

1.6 SUBMITTALS

A. Submit in accordance with Section 013323 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES and Section 270513, REQUIREMENTS FOR COMMUNICATIONS COMMON WORK RESULTS.
   1. Submittals shall also be marked to show specification reference including the section and paragraph number.
   2. Concurrent Review: For Architect-Engineer projects, submit additional three (3) copies of submittals.

B. Product Data: For each type of product indicated. Include the quantity, make and model number of each item.

C. Results of the TV Signal Survey.

D. Shop Drawings
   1. Narrative description of system.
   2. A List of the equipment to be furnished. The quantity, make and model number of each item is required.
   3. Headend cabinet and each distribution cabinet layout drawing, as it is to be installed.
   4. Equipment technical literature detailing the electrical and technical characteristics of each item of equipment to be furnished.
   5. Engineering drawings of the system, showing calculated signal levels at the headend output, at each input and output distribution point in the system proposed TV outlet tap values, and signal level at each TV outlet jack.
   6. Detailed schematics of subsystems, assemblies and subassemblies to component level, clearly presented, to determine compliance with drawings and specifications.

E. Field Quality Assurance:
   1. Test Plan: Submit the test plan prior to pretesting for evaluation and approval.
   2. List of test equipment.
   3. Letter certifying that the Contractor understands the requirements of the SAMPLES.
   4. Letter certifying that the Contractor understands the requirements of Part 3 concerning tests.
   5. Submit test reports.

F. Test Equipment List: Unless otherwise stated, the test equipment shall not be considered part of the system. Test equipment shall be of accuracy better than the parameters to be tested and shall have a calibration tag of an acceptable calibration service dated not more than 12 months prior to the test. The list shall include the make, model number of the following type of equipment as a minimum:

1. Spectrum Analyzer
2. Signal Level Meter
3. Volt-ohm Meter
4. Color TV Receiver
5. Hospital grade pillow speaker, with TV remote control cable terminating in the multi-pin connector.

G. Samples: A sample of each of the following items shall be furnished to the Resident Engineer for approval prior to installation. The samples may be returned to the Contractor at the discretion of the Resident Engineer.
   1. Wall Outlet Box 100 x 100 mm (4" x 4"), or two (2) 50 x 100 mm (2" x 4") outlet boxes, with:
      a. RF Outlet installed
      b. Multi-pin jack installed
      c. Stainless Cover Plate installed
      d. AC outlets installed
      e. Steel Partition installed
   2. TV Receiver RF Cable with connector, 600mm (24") section with cable sweep tag.
   3. TV Receiver Remote Control Cable with multi-pin connector installed.
   4. TV Wall Mount, as required.
   5. TV Ceiling Mount, as required.
   6. Wall Outlet Box 4" x 4" x 2.5" with:
      a. TV Outlet installed
      b. Multi pin jack installed
      c. Cover Plate installed
      d. AC Outlets installed
      e. Steel Partition installed

H. Pretesting Certification: After the system has been installed, aligned, balanced, pretested and found to meet the requirements of this specification, submit a letter to the Resident Engineer certifying that the system is ready for the formal acceptance test. Include a copy of the pretest measurements with the certification.

I. Manuals: Fifteen working days prior to the scheduled acceptance test, deliver four (4) complete sets of operation and maintenance manuals, for each item of equipment. The manuals shall detail the theory of operation and shall include narrative descriptions, pictorial illustrations, block and schematic diagrams and parts lists.

J. As-Installed Wiring Diagrams
   1. Fifteen working days prior to the acceptance test, deliver four (4) complete sets of as-installed wiring diagrams of the system(s). The diagrams shall show all inputs and outputs of electronic and passive equipment correctly identified according to the markers installed on the interconnecting cables. The wiring diagrams shall show the signal levels of the visual and aural carriers of each TV channel at the input and output of electronic equipment, beginning and end of each distribution line, and the TV outlets.
   2. The as-installed wiring diagrams shall be in hard copy and on standard CD-ROM or DVD disks, formatted to match the VAMC's current operating version of Automatic Computer Assisted Design (AUTO CAD) system, as provided by the Resident Engineer.

K. Guaranteed Period Services: List the entities that will certify the system and who will perform the guarantee period services. The listing shall include a company brochure, and name-title-normal and emergency telephone numbers of the individuals providing the services. Additionally provide the following, as required by the Warranty provisions:
   1. List of names and telephone numbers of maintenance personnel that have the ability to contact the OEM's central emergency assistance maintenance center.
   2. Copies of the OEM's training certificates of maintenance personnel.
   3. Contract and prepayment documentation of the business telephone.

L. Training Plan: Provide a detailed lesson plan specified in the "TRAINING" Article. This plan will be evaluated and approved by the office of Telecommunications.

## 1.7 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in text by basic designation only.

B. National Fire Protection Association (NFPA):
   1. 70-05……..National Electrical Code
   2. 780-04……..Standard for the Installation of Lightning Protection Systems
   3. 99-05……..Standard for Health Care Facilities

C. Underwriters Laboratories, Inc. (UL):
   1. 1410-97 (R01)……Television Receivers and High-Voltage Video Products
   2. 1069-01 (R06)……Standard for Hospital Signaling and Nurse Call Equipment

## 1.8 WARRANTY

A. Guarantee that installed material and equipment will be free from defects, workmanship, and will remain so for a period of one (1) year from date of final acceptance of the MATV System by Owner. Provide OEM's equipment warranty documents, to the Resident Engineer and Owner, certifying that equipment installed under this Section of the specifications conforms to the submittals.

B. Maintenance personnel shall have the ability to contact the Contractor and OEM's central emergency assistance maintenance center and request remote diagnostic testing and assistance in resolving technical problems at any time, 365 days a year. This capability shall be provided by the Contractor and OEM via a business telephone line at no additional cost to Owner. Each maintenance and supervisor individual shall be fully qualified by the OEM. Provide the Resident Engineer and Owner with copies of current and qualified OEM training certificates and OEM certification.

C. Additionally, defining the FAR's warranty outlines concerning this system, accomplish the following minimum requirements during the one-year warranty period:

D. Response time during the one-year warranty period:

1. Respond on-site, during the standard work week, to a routine trouble call within 72 hours of its report. Routine trouble is considered a trouble which causes a TV outlet to be inoperable.
2. Respond on-site to an emergency trouble call within 24 hours of its report. An emergency trouble is considered a trouble which causes a subsystem to be inoperable at any time.
3. Respond on-site to a catastrophic trouble call within 12 hours of its report. A catastrophic trouble call is considered an MATV failure.
   a. If a MATV failure cannot be corrected within eight (8) hours, provide alternate MATV equipment. The alternate equipment/system shall be operational within 12 hours (to commence at the end of the eight (8) hour trouble shooting period).
   b. Failures affecting operation of critical emergency health care facilities (i.e., cardiac arrest teams, and intensive care units) shall also be deemed as a catastrophic trouble call if so determined by the Owner. The Owner shall notify the Contractor of this type of trouble call at the direction of the Owner.
4. A standard work week is considered 8:00 AM to 5:00 PM, Monday through Friday exclusive of Federal Holidays. If any trouble cannot be corrected within one (1) working day, provide compatible substitute equipment returning the system or subsystem to full operational capability, as described herein, until repairs are complete.
5. The Owner is the reporting and contact official for MATV System trouble calls, during the guaranty period.

## PART 2 - PRODUCTS

### 2.1 EQUIPMENT AND MATERIALS

A. MATV equipment shall be new and the current model of a standard product of an original manufacturer whose main business is the manufacture for sale of items of equipment supplied and which comply with the following:
   1. Maintains a factory production line for the item submitted.
   2. Maintains a stock of replacement parts for the item submitted.
   3. Maintains engineering drawings, specifications, and operating manuals for the items submitted.
   4. Has published and distributed descriptive literature and equipment specifications on each item of equipment offered.

### 2.2 EQUIPMENT COMPATIBILITY

A. When electrically associated with other equipment, the total system shall be designed and installed so that the combination of equipment actually employed does not produce undesirable effects such as signal distortion, noise pulses, glitches, hum bars, transients, ghosting, tilting and flutter.

## 2.3 GENERAL EQUIPMENT REQUIREMENTS

A. Active component equipment shall consist of solid-state components, be rated for continuous duty service, and be provided with “F” connectors unless otherwise specified.

B. Passive distribution equipment shall be provided with “F” connectors.

C. Antennas and their support shall withstand adverse local environmental conditions and 100 miles per hour (MPH) winds without damage.

D. Trunk, branch and interconnecting coaxial cables and unused ports/taps shall be terminated with a 75 Ohm terminating resistor designed for TV cable systems without adapters.

E. Equipment Functional Characteristics:

F. Service Conditions: Intercommunications equipment shall be capable of operating continuously in the following environmental conditions without mechanical and electrical damage or degradation of service:
   1. Input Voltage : 120 V rms plus or minus 10 percent
   2. Input Frequency: 60 Hz
   3. Ambient Temperature: Zero to 40 degrees C.
   4. Humidity: 0 to 80 percent relative, non-condensing.
   5. Antennas and their support shall withstand adverse environmental conditions and 161 km/h (100 mph) winds without damage.

## 2.4 HEADEND EQUIPMENT

A. Broadband Amplifier: Rack-mounted, UL listed, the amplifier shall accept individual VHF and UHF antenna inputs with gain and/or slope controls for each band. If separate VHF and UHF inputs are not available, the individual VHF and UHF antenna inputs shall be mixed or combined and balanced to provide equal signal level to the single amplifier input. The amplifier output shall provide for a minimum of 35 adjacent TV channel operations with separate adjustable gain and slope controls:
   1. Frequency Response: Plus or minus 1.5 dB, 54-450 mHz minimum.
   2. Noise Figure: 10 dB maximum
   3. Output Capability: 45 dBmV minimum, for 35 TV channels
   4. Cross Modulation: minus 46 dB
   5. Gain Control Range: 10 dB
   6. Slope Control: 0-8 dB @ 400 mHz
   7. Connectors: “F”
   8. Impedance: 75 Ohm

## 2.5 DISTRIBUTION EQUIPMENT

A. Amplifier, Broadband: The broadband amplifier shall provide 35 adjacent TV channel operation with separate adjustable gain and slope controls. It shall be UL approved with integral lightning/surge protection.

1. Frequency Response: Plus or minus 1.5 dB, 54-300 mHz.
2. Noise Figure: 10 dB maximum
3. Output Capability: 45 dBmV minimum, 35 channels.
4. Cross Modulation: Minus 46 dB
5. Gain Control Range: 10 dB
6. Slope Control: 0-8 dB at 300 mHz.

B. TV Receiver Wall Outlet:
1. The TV receiver wall outlet shall consist of an RF jack and where required, a remote-control multi-pin jack mounted in a steel outlet box. When installed with a duplex hospital grade AC outlet, a partitioned 100 by 100 mm (4 by 4 inch) or 50 by 100 mm (2 by 4 inch) steel outlet box shall be used.
2. The wall outlet shall be fed from a directional coupler multi-tap or be an additional directional coupler in order to balance the system.
3. Interface of the Nurse Call Pillow Speaker Unit to the installed remote control multi pin jack for remote control of the TV receiver is the responsibility of the Nurse Call installer; not the TV system installer.
4. The wall outlet shall be provided with cover plate(s) to fit the TV Jack, multipin jack and the outlet box provided.

## 3.2 COAXIAL CABLE:

A. The coaxial cable shall be double shielded, certified 100% sweep tested by the manufacturer by tags on each reel. The tags and a 600 mm (24") sample shall be delivered to the Owner prior to installation. The cable shall be able to pass the frequency spectrum from 5 to 890 MHz and have a return loss of not more than 26 dB.

B. RG-6 Coaxial Cable:
1. Center Conductor: 18 AAWG copper-clad steel.
2. Dielectric: Foam
3. Jacket: Black PVC or PE, UL 1685 Type CATV or CM.
4. Temperature Rating: 80 C
5. Impedance: 75 Ohm
6. Attenuation for the following frequencies at a maximum indicated dB per 30 m (100 feet):
   a. 7 MHz: 0.6
   b. 54 MHz: 1.8
   c. 216 MHz: 3.5
   d. 470 MHz: 4.7
   e. 890 MHz: 7.0

C. RG-11 Coaxial Cable:
1. Center Conductor: 14 AWG copper-clad steel
2. Dielectric: Polyethylene
3. Jacket: Black PVC or PE, UL 1685 Type CATV or CM.
4. Temperature Rating: 80° C
5. Impedance: 75 Ohm

6. Attenuation for the following frequencies at a maximum indicated dB per 30 m (100 feet):
   a. 7 MHz: 0.31
   b. 54 MHz: 1.10
   c. 215 MHz: 2.40
   d. 470 MHz: 3.80
   e. 890 MHz: 5.60

## 3.3 TV RECEIVER CONNECTIONS

A. Coaxial Cable: Provide one (1) connecting cable for each TV outlet in the MATV system plus 10% spares. The cable shall connect the TV receiver to the RF jack.
   1. Length: 6 feet
   2. Cable: RG-6 double shielded type.
   3. Connector: Snap-on “F” at MATV outlet end and screw-on “F” at receiver end.

B. Remote Control Cable: Provide one (1) multi-conductor connector cable for each TV outlet in the system plus 10% spares. The cable shall connect the TV receiver remote control circuits to the multi-pin jack.
   1. Length: 6 feet
   2. Cable: 5 conductors minimum, stranded copper.
   3. Connector: Multi-pin plug at the outlet end and no connector at the receiver end.
   4. Working Voltage: 200 Volts

C. TV Receiver Matching Transformer: Provide 75 ti 300 Ohm matching transformers, in a quantity equal to 10% of the TV wall outlets. The matching transformer shall have metal case or other means to reduce local pickup (ghosting) at the TV receiver input.
   1. Insertion loss: UHF – 1.5 dB, VHF – 0.5 dB
   2. Return loss: UHF – 12 dB, VHF – 20 dB
   3. Balance: UHF – 30 dB, VHF – 35 dB

D. TV Receiver Ceiling/Wall Mount:
   1. Install mounts where indicated, using factory made accessories, braces and back plates, as needed for secure mounting.
   2. The mount shall be able to be swiveled, tilted and locked, and be adjustable in width for 19” TV receivers.
   3. The installation of mounts shall be approved by the Resident Engineer. Allow at least 78 inches headroom under the mount when installed in a location where personnel may walk directly under it.

E. TV Receiver Ceiling/Wall Mount:
   1. A complete assembly (to include a wall or ceiling mounting adapter [with appropriate length of pipe, supports, and ceiling tile trim rings for ceiling mounts] and TV receiver attaching bracket) shall be provided for each ceiling and/or wall TV outlet shown on the drawings. It shall be firmly anchored to a secure structure. Provide braces and back plates if required.
   2. The TV receiver attaching bracket shall be able to be swiveled, tilted and locked, and be adjustable in width for 20-inch minimum CATV cable ready TV receivers.

3. The installation of these mounts shall be approved by the Engineer in writing prior to installation. The TV mount assembly installation (including brackets) shall provide sufficient space for 20-inch diagonal CATV cable ready TV receiver and a minimum of 4 inches of clearance between the ceiling and top of the TV receiver. A minimum of 78-inch headroom under the mount shall be provided when it is installed in a location where personnel are subject to walk directly under it.

## 3.4 RF CONNECTORS

A. "F" Connectors: Screw type coupling for quick connect/disconnect of coaxial cable terminations. Crimp on integral ferrule connector designed to fit the coaxial cable furnished.
   1. Working Voltage: 500 V
   2. Frequency Range: 0 to 890 MHz
   3. Impedance: 75 Ohms

B. Coaxial Cable Terminators: These units shall be metal housed precision types in the frequency ranges selected.
   1. Frequency:
      a. 5-890 MHz
      b. 200-1,500 MHz
      c. 3,000-5,000 MHz
   2. Power Blocking: As required, 1.5:1 maximum
   3. Return Loss: 25 dB
   4. Connectors: "F", "BNC"
   5. Impedance: 75 Ohms

# PART 3 - EXECUTION

## 3.1 GENERAL

A. Install equipment according to NFPA 70, accepted industry standards of good practice, the requirements of this specification, and in a manner which does not constitute a safety hazard:
   1. Comply with NECA 1.

B. Ensure that all installation personnel understand the requirements of this specification.

C. Install suitable filters, traps, and pads for minimizing interference and for balancing the amplifiers and distribution system.
   1. Filters, splitters, couplers, tap-offs, matching transformers and TV wall outlets shall be able to pass color TV channels in the frequency bands selected, in the directions specified, with low loss, and high isolation and with minimum delay of the color subcarrier frequency.
   2. Install all equipment necessary to meet the requirements of Part 2 paragraph "Equipment Compatibility" and the system performance standards.

D. Connect passive equipment according to the manufacturer's specification to ensure correct termination, isolation impedance match, and signal level balance at each outlet.

E. Identification: Cables shall be labeled with permanent markers at the terminals of the electronic and passive equipment. The lettering on the cables shall correspond with the lettering on the as-installed diagrams.

F. Outlet Installation: Where TV receivers are installed adjacent to each other in bedrooms, install MATV outlets for each receiver.

G. Cable Terminations:
   1. All lines shall be terminated in a suitable manner to facilitate future expansion of the MATV system. There shall be a minimum of one (1) spare output at each distribution point on each floor.
   2. Terminating resistors shall be used to terminate all unused branches, outlets and unused equipment ports of the system and shall be devices designed for the purpose of terminating coaxial cable carrying TV signals in MATV systems.
   3. Equipment installed outdoors should be weatherproof or installed in weatherproof enclosures with hinged doors and locks with two (2) keys.

## 3.2 SYSTEM CABLING

A. Install cabling in raceway, and cable tray, except within cabinets. Conceal raceway and cables, except in unfinished spaces. MATV cables should not be installed in AC power conduits.
   1. Cable in raceway shall be NFPA Type CMG.
   2. Cable in cable tray in environmental air spaces, including plenum ceiling spaces, shall be NFPA Type CMP.

B. Raceway and boxes shall be as specified in Section 270533, RACEWAYS AND BOXES FOR COMMUNICATION SYSTEMS.

C. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets, equipment terminals, and in terminal cabinets. Cables may not be spliced:
   1. Connectors shall be installed using the connector manufacturer's approved crimping tool.

D. Cold-weather installation: Bring the cable to room temperature before derailing. Heat lamps may not be used.

## 3.3 AC POWER

A. Connect all branch AC circuits which supply power to the MATV system to a single panel board and shall clearly indicate on the directory in the panelboard that the circuits supply power to the system.

B. Install a 120-volt AC branch circuit, wired to a separate breaker, from the power panel to each equipment cabinet.
   1. Provide AC power outlets that are convenient to each item of equipment in the equipment cabinet and for each TV receiver wall outlet.

## 3.4 GROUNDING

A. Ground installed equipment in accordance with the Section 270526, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS to eliminate shock hazards and to minimize ground loops, noise pickup, or other inferences.
   1. Ground wires for equipment shall be at least No. 14 AWG stranded copper wire.
   2. Ground wires for equipment cabinets or racks shall be at least No. 10 AWG stranded copper wire.
   3. Bond the antenna masts securely to the earth ground. Ground wires for antenna masts shall be not less than No. 6 AWG stranded copper wire.

## 3.5 EQUIPMENT ASSEMBLY

A. Equipment installed indoors shall be installed in equipment cabinets so as to be accessible for maintenance without interference with other nearby equipment.

B. Equipment should be installed with sufficient vertical separation to ensure adequate air circulation. Any cabinet, in which the ambient temperature shall exceed 45 degrees C at the top, shall be equipped with a quiet thermostatically controlled fan. The cabinet should be designed to provide air flow around equipment.

C. Cables shall enter the equipment cabinets in such a manner that doors shall open and close without disturbing or damaging the cables.

## 3.6 TESTS

A. Pretesting
   1. Upon completing installation of the MATV system extension, align, balance and completely pretest the entire MATV system. After pretesting and only after pre-testing, the system shall be formally tested in the presence of Owner's representative.
   2. During the system pretest, verify (utilizing the approved spectrum analyzer and signal level meter) that the system is fully operational and meets system performance requirements of this specification.
   3. Measure and record the visual and aural carrier levels of each channel at each of the following points:
      a. Antenna outputs
      b. Preamplifier inputs and outputs
      c. Strip amplifier or Channel Processor inputs and outputs.
      d. Head-end signal level and signal-to-noise ratio for each TV channel specified.
      e. Distribution amplifier inputs and outputs
      f. Last outlet or splitter of each feeder.

g. A random sample of 25% of TV outlets, selected by the Engineer.

4. After pretest measurements are made, the system shall be left to "burn-in" until the final inspection is completed.
5. A copy of the recorded system pretest measurements and the written certification that the system is ready for the formal acceptance test shall be submitted to the Engineer.

B. Acceptance Testing
1. Notify the Engineer in writing seven (7) days after the pretest has been completed and 30 days prior to the date acceptance testing is expected to begin. Test system in the presence of Owner's representative. Verify that the total system meets the requirements of the specification and complies with the appropriate standards listed in this specification.
2. The notification of the acceptance test shall include the expected length of the test in days.
3. The acceptance test shall be performed on a "go/no-go" basis. Only those operator adjustments required to show proof-of performance shall be allowed. The test shall demonstrate and verify that the installed MATV system does comply with the operational and technical requirements of this specification under operating conditions. The MATV system shall be rated as either acceptable or unacceptable at the conclusion of the rest. Failure of any part of the system which precludes completion of system testing, which cannot be repaired in four (4) hours, shall be cause for terminating the test of the MATV system. Repeated failures which result in a cumulative time of eight (8) hours to effect repairs shall cause the entire MATV system to be declared unacceptable. Retesting of the entire MATV system shall be rescheduled at the convenience of the Owner.

C. Acceptance Test Procedure:
1. Inspection:
   a. The Owner's representative will tour major areas to ensure that MATV systems are completely and properly installed in place, and are operationally ready for proof-of-performance testing. Failure of the MATV system to meet the installation requirements of this specification shall be grounds for terminating all testing.
   b. The system diagrams, as-installed drawings, equipment manuals, AUTO CAD Disks, and pretest measurements shall be formally inventoried and reviewed before testing is resumed.
2. Test
   a. After the inspection, the headend output shall be checked to verify that it meets performance requirements utilizing the spectrum analyzer or signal level meter.
   b. Following the Signal Level Test, a CATV cable ready color TV receiver shall be connected to the headend output test to ensure there are no visible signal distortions such as intermodulation (windshield wiper effect), ghosting, and beats on any channel.
3. Distribution System Testing:
   a. Using a spectrum analyzer or signal level meter, and a TV receiver, check the first and last outlet in each feeder of the MATC distribution system, to verify that the distribution system meets performance requirements. Test functions of TV outlets, that are controlled by a Nurse Call Pillow Speaker, at the same time.
   b. Test a random sample of at least 25% of the TV outlets, selected by the Engineer, for signal level and for picture quality with a color receiver; unless incorrect levels indicate that a wider sample should be taken.
4. Revise as-installed wiring diagrams to show adjustments made during acceptance testing.

3.7 TRAINING

A. Furnish the services of an OEM trained engineer or technician for a total of eight (8) hours to instruct designated maintenance personnel. Instruction shall include corrective and preventive maintenance of the MATV equipment. Before the system can be accepted by Owner, this training must be accomplished. Training will be scheduled at the convenience of the Owner.

**END OF SECTION**

**SECTION 275129**

**RESCUE ASSISTANCE SIGNAL SYSTEM**

PART 1 - GENERAL

1.1 SCOPE

A. Furnish, install, and wire all equipment associated with the installation of a Digital Area of Refuge/Area of Rescue Assistance Signal System designed for IBC-2015 and ADA (Americans with Disabilities Act) requirements. This work shall include a Base Station(s), the main system, optional expansion modules for larger systems, remote call stations, power supply(s), outlet boxes, cables and wiring as shown on the drawings and as specified herein.

B. Section Includes:
   1. Area of Refuge/Elevator Landing Two-Way Communication Systems with the following components:
      a. Call Commander (Master Station)
      b. Distribution Module (BOSS)
      c. Call Boxes
      d. Power Supply
      e. Accessories

1.2 SUBMITTALS

A. General: 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 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 and operation manual.
   3. Manufacturer’s Field Reports: Manufacturer’s field reports specified herein.

E. Closeout Submittals: Submit the following:
   1. Operation and Maintenance Data: Operation and maintenance data for installed products in accordance with Division 1 Closeout Submittals. (Maintenance Data and Operations Data) Section.
   2. Manufacturer's Warranty: 2 years from date of shipment.

F. Project Closeout
   1. A one-year maintenance contract offering continued factory-authorized service of this system will be provided as part of this contract.
   2. The contractor shall furnish manufacturer's manuals of the completed system including individual specifications sheets, schematics, inter-panel and intra-panel wiring diagrams.
      a. All information necessary for the proper maintenance and operation of the system must be included.
      b. Provide four (4) copies.
   3. As-built drawings that include changes to wiring, wiring designations, junction box labeling, and other pertinent information shall be supplied upon completion of the project.
   4. Provide a minimum of two (2) hours of in-service training with the system.
      a. These sessions shall be broken into segments that will facilitate the training of the system users in operating station equipment.
      b. Operating manuals and user guides shall be provided at the time of training.

## 1.2 REFERENCES

A. National Fire Protection Association (NFPA)

B. International Building Code (IBC)

C. Americans with Disabilities Act (ADA)

## 1.3 WARRANTY

A. Project Warranty: Refer to Conditions of the Contract for project warranty provisions.

B. Manufacturer's Warranty: 2 years from date of shipment.

## 1.3 INSTALLATION STANDARDS

A. The system shall be installed in accordance with the IBC-2009 and ADA requirements.

B. The completed system shall be in compliance with state and local electrical codes.

C. All wiring shall test free from grounds and shorts.

D. Install according to manufacturer's wiring diagrams.

E. The Area of Refuge Emergency Communications System requires installation by factory trained authorized dealers/distributors, in accordance with ANSI/NFPA 70 National Electrical Code and NFPA 72 Fire Alarm Code.

F. Properly trained personnel, familiar with Telecommunications Industry Association 568 TIA/EIA Standard, are required for proper installation. Failure to terminate the wiring correctly will cause damage to the system and void the warranty.

G. The Area of Refuge Emergency Communication System shall be installed in a controlled, indoor dry environment, with temperatures maintained between 55°F and 95°F.

## 1.4 SYSTEMS OPERATIONS

A. Furnish, install and place into operation an Refuge/Rescue Assistance System as indicated on the drawings and as specified herein.

B. A base station (2500-205PSS series) shall be provided at the main building entrance or other location, as authorized by local authority or the fire department, where shown on the drawings to indicate light and tone signals from multiple remote call stations and allow voice communication. Optionally, secondary base station phones can also be installed throughout the building to allow alternate locations to respond to a call for assistance.
   1. When the system is operational, an LED signals power on all devices.
   2. When the remote call station switch is activated, a customizable message is made at the call station, an LED in the button flashes. After the initial customizable message plays, a ringing tone is heard at the remote call station while the station is being connected to the Base Station(s). The call is displayed digitally on the Base Station(s) phone with a ringing tone, red LED flashes to indicate an incoming call, along with a display of the call and its location.
   3. When the alarm signal is answered by the Base Station, the remote call station is signaled by the LED flashing that voice communication is initiated.
   4. Voice communication with the remote call station can then be initiated from the Base Station via a handset.
   5. External modem connection to a public telephone system shall be provided after a programmable time delay.
   6. The system shall poll (supervise) all the call stations and base stations on a continuous basis to identify line faults and defective equipment. Faults can be programmed to alert by initiating a call at all base station phones or to an offsite monitoring location. When a fault call is answered, a programmable message will play indicating the specific device or connection the fault originated from. Optionally, SMS/text messaging is available as notification of specific fault conditions.

## 1.5 QUALITY ASSURANCE

A. Installer Qualifications: Company specializing in performing work of this section with minimum of one-year documented experience with projects similar scope and complexity.
   1. Approved by Manufacturer.

B. Provide each type of product with a single manufacturing source to ensure uniformity.

C. Store in a location that will protect from damage due to weather, excessive temperature, or other construction operations.

D. System shall be installed in compliance with all state and local electrical codes.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Acceptable Manufacturer:
   1. RATH Communications, located at N56 W24720 North Corporate Circle; Sussex, WI 53089; Phone: 800-451-1460; Website: www.rathcommunications.com
   2. Cornell
   3. Or an approved equal to.

B. Substitutions are not permitted.

### 2.2 CALL COMMANDER (MASTER STATION)

A. The Call Commander is to be located at a central control point on the first floor.

B. Call Commander(s) shall be connected to designated ports on the Distribution Module.

C. Call Commander(s) shall wire to the Distribution Module using two wire pairs.
   1. Call Commander cabling used shall be RATH Cable RP7500094B or equivalent. Where local municipal codes require CI 2-hour fire-rated cable, RATH Part #66120 shall be used.

D. Must comply with ADA requirements.

E. The Call Commander shall be surface, flush, or desk mounted.

### 2.3 CALL BOXES

A. Call Boxes (3300FSN series) must be in full compliance with ADA requirements. Call Boxes require a hands-free speakerphone with an LED to indicate status of call.
   1. Call Boxes are to be located no higher than 48” front reach or 54” side reach to the center of the button above ground level.
   2. Call Boxes must include braille identifying the unit as an “Emergency Phone.”
   3. Where local municipal codes require, Call Boxes shall include a protective cover (RATH Part #3300FSCN or 3300SSC).
   4. Call Boxes shall include a button with a diameter of 1 inch or greater.

B. Call Boxes shall be connected to designated ports on the Distribution Module.
   1. Call Boxes shall be daisy-chained from the Distribution Module.
   2. A Call Box Loop shall support up to 24 Call Boxes.
   3. A maximum of 2 Loops may be installed on a single system.
   4. Call Boxes shall wire to the Distribution Module using two wire pairs.
   5. Call Box cabling used shall be RATH Cable RP7500094B or equivalent. Where local municipal codes require CI hour fire-rated cable, RATH Part #66120 shall be used.

C. Call Boxes shall be an ADA compliant and vandal resistant speakerphone.

D. Call Boxes shall be wall-mounted flush.

## 2.4 DISTRIBUTION MODULE (BOSS)

A. Includes connections for Call Boxes and Call Commanders.

B. Distribution Module shall be wall mounted or rack mounted.

C. Distribution Module shall be powered by a manufacturer approved power supply and battery backup (Part #1000).

D. System and Call Box programming shall be done via the BOSS.

## 2.5 POWER SUPPLY

A. The system shall be powered by an approved power supply (Part #2500-PWR24U).

B. The power supply shall be wall mounted or rack mounted.

## 2.6 ACCESSORIES

A. Signage
   1. One location and instruction sign (Part #7049SS) to clearly indicate location of designated area at each Call Box.
   2. One tactile sign (Part #7043/7044 or 7087) with raised letter and braille shall be located at the entrance area where a Call Box is installed.
   3. One illuminated egress sign (7041/7041E or 7050/7050E) in the area where each Call Box is installed.
   4. Tactile signage shall comply with ADA requirements.

B. Cabling
   1. Cabling for two-way communication shall meet the applicable requirements for pathway survivability, Cabling used for installation shall consist of one or more of the following:
      a. 2 Pair UL Listed Plenum Rated Cable – RATH Part #RP7500094B.
      b. 2 Pair UL Listed Circuit Integrity (CI) 2-hour fire-rated cable – RATH Part #66120.

c. 2-hour fire-rated cable system.
2. 2-hour fire-rated enclosure of protected area.

## 2.7 PERFORMANCE REQUIREMENTS

A. Call Boxes
1. Call boxes shall allow for programming of a specific location message of the unit to allow rescue personnel to know the location of the activated Call Box.
2. Call Boxes should be hands-free and require a single button push to initiate a call.
   a. Once the button is pushed the Call Box shall call the Call Commander. If there is no answer the system must be capable of automatically dialing a preprogrammed emergency number.
   b. Once a call has been made, the call can only be terminated by the called party.
   c. Call Box shall include an LED indication of when the call has been placed and received.
3. The Call Box shall have location message capability. Each Call Box must have the same capability to record a minimum 18-second message.
   a. The message shall be programmable to play 1 or 2 times.
   b. The message shall be played for both the calling and receiving party.
   c. The message shall be recorded through voice or text-to-speech software.

B. Call Commander
1. The Call Commander must provide an audible and visual indicator so that a Call Box has been activated.
2. The Call Commander shall be capable of displaying the location of each call box.
3. The call commander shall display each active call box and have unique indicators if the call boxes are connected onsite, or on hold.
   a. Active calls shall be displayed in the order they were placed.

C. Distribution Module (BOSS)
1. BOSS shall include visual indicators of a Call Box failure.
2. The power supply shall require 120vac power and provide battery backup for a minimum of 24 hours standby and 5 minutes active talk time.
3. The BOSS shall annunciate primary power loss, Call Box activation, and system faults both audibly and visually.

D. Certifications
1. Primary system components shall be compliant with FCC Part 15.
2. Fire-rated cabling shall be certified to UL 2196 by a Nationally Recognized Testing Laboratory (NRTL).
3. Plenum cabling shall be certified to UL 444 by a NRTL.
4. Backup battery/uninterruptible power systems shall be certified to UL 1778 or equivalent standard by a NRTL.

PART 3 - EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

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 the other sections, are acceptable for product installation in accordance with manufacturer's instructions.

3.3 PREPARATIONS

A. Prepare surfaces using methods recommended by manufacturers for achieving the best results.

3.4 INSTALLATION

A. Install in accordance with manufacturer's instructions, approved submittals, and in proper relationship with other construction.
   1. Install equipment firmly secured and level.
   2. Cable runs shall be tagged and identified at main terminal board and junction boxes.

3.5 STARTUP AND TESTING

A. Include all software necessary for system configuration.

B. Turn on system and adjust as necessary to meet indicated requirements.

C. Program system as specified.

D. Test system to ensure all components, stations, speakers, and accessories are working properly.

3.6 CLEANING

A. Cleaning: Repair or replace damaged installed products. Remove construction debris from project site and legally dispose of debris.

**END OF SECTION**

**SECTION 283100**

**FIRE DETECTION AND ALARM**

PART 1 - GENERAL

1.1 SCOPE

A. Perform all Work required to provide a complete, addressable campus-wide fire alarm system consisting of a master fire alarm control panel located within the Maintenance Building and networked fire alarm control panels located in each building throughout the campus. The Maintenance Building fire alarm control panel shall serve as the master panel and shall provide centralized monitoring, supervision, annunciation, event logging, and status reporting for all networked fire alarm control panels on the campus. Each building fire alarm control panel shall operate as an independent fire alarm system while simultaneously communicating with the master panel via the campus fire alarm network. Alarm, supervisory, trouble, and system status conditions originating at any building shall be transmitted to and annunciated at the master panel. The fire alarm network shall be configured such that a single communication failure does not impair the ability of individual building systems to perform their required life safety functions. Provide all network interfaces, communication equipment, fiber optic connections, programming, and accessories required for a complete and fully operational campus-wide fire alarm system. The campus fire alarm network shall utilize fiber optic communication between buildings. Copper communication circuits between buildings shall not be permitted. The fire alarm system manufacturer shall be responsible for providing all equipment necessary to network the individual building fire alarm control panels with the master fire alarm control panel located in the Maintenance Building

1.2 REFERENCES

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

B. Related Sections
   1. Division 01 General Requirements
   2. Division 07 Thermal and Moisture Protection, Section 078413 Penetration Firestopping
   3. Division 08 Openings, Section 087100 Door Hardware
   4. Division 21 Fire Suppression
   5. Division 23 Heating Ventilating and Air Conditioning Monitoring & Control (HVAC)
   6. Division 26 Electrical, Section 260500 Common Work Results for Electrical

1.3 SUBMITTAL

A. Title page with an accurate legend of symbols for all fire alarm devices being installed. The legend must include the quantity and model number for each device.

B. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Complete manufacturer's catalog data including supervisory power usage, alarm power usage, physical dimensions, and finish and mounting requirements.

C. Battery capacity calculations: Battery size shall be a minimum of 125% of the calculated requirement. Provide the following supporting information:
   1. Supervisory power requirements for all equipment.
   2. Alarm power requirements for all equipment.
   3. Power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst-case condition plus 25% spare capacity. This shall include anticipated devices in tenant areas where the base design is a building shell. Coordinate anticipated device layout with Engineer.
   4. Voltage drop calculations for wiring runs demonstrating worst-case condition.
   5. NAC circuit design shall incorporate a 15% spare capacity for future expansion.
   6. When audible notification devices are added to existing systems the submittal shall include a power availability analysis showing the intended source of audio, the amplifier used, the notification circuit capacity and standby power availability. All manufacturers' data pertaining to audible circuits such as noise suppression and wiring limitations shall be included in the submittal.

D. Drawings
   1. Prepare drawings using AutoCAD software and include all Contractors' information. The Contractor shall be responsible for verifying all critical dimensions shown on the drawings provided by the Architect.
   2. Floor plans: Provide locations for all devices, new and existing (with device number at each addressable device corresponding to control unit programming), appliances, panels, power boosters, equipment, junction / terminal cabinets, risers, electrical power connections individual circuit and raceway routing, number size and type of raceways, and conductors in each raceway. Conduit fill calculations with cross section area percent fill for each type of conductor and raceway. Show all interfaces for all fire safety functions. Identify all fire rated walls within the Project area. Coordinate with Construction Documents
   3. Riser diagrams: Provide, for the entire system, the number, size and type of riser raceways and conductors in each riser raceway and number of each type of device per floor and zone. Show door holder interface, elevator control interface, HVAC shutdown interface, fire extinguishing system interface, and all other fire safety interfaces. Show wire styles on the riser diagram for all circuits. The riser schematic shall show locations of all control panels, transponder cabinets, terminal cabinets, NAC power supplies. Locations shown shall be identified by room number.
   4. A wire list showing the wire type, gauge, and conductor count for all wires and cables.
   5. Complete system point-to-point wiring diagrams with appropriate terminal designations and schematics for all components provided and for interfaces to equipment and cabling supplied under other Divisions or by the Owner.
   6. Show campus network interface detail including all modems and interconnections necessary for a fully functional network interface.

7. Detailed wiring diagrams: Provide for control panels, modules, power supplies, electrical power connections, auxiliary relays, and annunciators showing termination identifications, size and type conductors, circuit boards, led lamps, indicators, adjustable controls, jumpers, switches, connectors, harnesses terminal strips and connectors. Diagrams shall be drawn to a scale sufficient to show the spatial relationships between components, enclosures and equipment configuration.
8. Duct air velocity where each duct smoke detector employing the use of sampling tubes is installed. Coordinate with Mechanical Contractor and Construction Documents.
9. Provide a fire alarm system function matrix as referenced by 2010 NFPA 72, Figure A.14.6.2.4(9). Matrix shall illustrate alarm input/out events in association with initiation devices. Matrix summary shall include system supervisory and trouble output functions. Include any and all departures, exceptions, variances or substitutions from these specifications and/or drawings at time of bid.

E. Sequence of Operation
1. Submittal shall include a complete written sequence of operations of all functions of the system.
2. In addition to the written sequence of operations, all sequence functions shall be depicted using a sequence of operations matrix chart of all functions showing how the system will react to the activation of each type of device, as recommended by 2010 NFPA 72, Figure A.14.6.2.4(9).
3. Submittal shall include details of all interfaced functions. Details shall include all fire alarm system functions and interconnections applicable to each interface.

F. Operation and Maintenance Data: For all fire alarm equipment, to include in operation and maintenance manuals.

G. Warranty: Sample of special warranty.

## 1.4 QUALITY ASSURANCE

A. Each and all items of the fire alarm system shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by Underwriters' Laboratories, Inc. (UL), and shall bear the "U.L." label. All control equipment shall be listed under both UL category UOJZ Control Units System as a single unit and under UL category APOU Proprietary Alarm Units. Service under APOU shall be Grade A. Partial listings, or multiple listings for various major sections of the control, shall not be acceptable.

B. The complete installation is to conform to the applicable sections of NFPA 72, NFPA 90A, NFPA 101, State and Local Code Requirements, NFPA 70 the National Electrical Code with particular attention to Article 760.

C. Additionally, the entire installed system and all integrated system operations shall be within the guidelines of the International Building Code, 2015, the Americans with Disabilities Act, Public Law 101-336, and the FM Global (Factory Mutual (FM)): FM Approval Guide.

D. All control equipment shall have transient protection devices to comply with UL864 requirements.

E. The system controls shall be UL listed for Power Limited Applications per NEC 760. All circuits shall be marked in accordance with NEC 760-23.

F. Supplier Qualifications
   1. The document submittal preparation and supervision of installation and testing shall be provided by a technician that is certified NICET level III or a registered fire protection engineer. The NICET certified technician shall be on site for the supervision and testing of the system. Factory engineers from the equipment manufacturer, thoroughly familiar and knowledgeable with all equipment utilized, shall provide additional technical support at the site as required by the Owner or his authorized representative.
   2. Provide the services of a factory trained and certified representative or technician, experienced in the installation and operation of the type of system provided. The representative shall be licensed in the State if required by law.
   3. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system. The technician shall provide the required instruction to the owner's personnel in the system operation and maintenance.
   4. The supplies shall furnish evidence they have an experienced service organization, which carries a stock of spare and repair parts for the system being furnished.
   5. The equipment supplier shall be authorized and trained by the manufacturer to calculate, design, install, test, and maintain the air sampling system and shall be able to produce a certificate stating such upon request.

G. Installer Qualifications
   1. Installers shall have a minimum of five (5) years' experience installing fire alarm systems.
   2. Contractors unable to comply with the provisions of Qualification of Installers shall present proof of engaging the services of a subcontractor qualified to furnish the required services.

## 1.5 SUMMARY

A. This Specification describes a fire detection and alarm system. The features and capacities described in this Specification are required as a minimum for this project and shall be furnished by the successful contractor.

B. The system shall be in full compliance with national and local codes.

C. The system shall include all required hardware, conduit and fittings, raceways and wiring, firmware, and software to accomplish the requirements of this specification and the contract drawings, whether or not specifically itemized herein.

D. The Contractor shall perform all Work in accordance with the Drawings and Specifications, and subject to the terms and conditions of the Contract. Work shall include, but not be limited to, the following:
   1. Fire alarm panel.
   2. Remote annunciator(s).
   3. Automatic smoke and heat detection.

4. Manual alarm initiation.
5. Air handling unit (AHU) controls to integrate AHU into the fire alarm system operation (where applicable).
6. Monitoring of sprinkler water flow and supervisory alarm switches.
7. Alarm annunciation.
8. Elevator recall.
9. Elevator machine room pre-action sprinkler system and equipment shutdown (Shunt Trip).
10. Smoke damper control (where applicable).
11. Monitoring of suppression system activation and supervisory alarm switches.

E. All equipment furnished shall be new and the latest state of the art products of a single manufacturer, engaged in the manufacturing and sale of fire alarm systems for over five (5) years.

F. The system as specified shall be supplied, installed, tested and approved by the local authority having jurisdiction, and turned over to the Owner in an operational condition.

G. In the interest of job coordination and responsibilities the installing contractor shall contract with a single supplier for fire detection and alarm equipment, engineering, installation, programming, and inspection and tests.

## 1.6 UNIT PRICES

A. List of Unit Price Items and Descriptions: Base bid quantities of fire alarm devices are shown on Drawings and shall be included in the Lump Sum Base Bid. Provide unit prices to add or delete fire alarm devices and maintain a complete and functioning system. Adjustment to add or delete quantities will be made by Change Order to the Contract Sum.
   1. Cost to provide device and complete installation, engineering and drawings, programming and testing for an addressable manual fire alarm station as detailed on the Drawings and Specifications. Unit price per addressable manual fire alarm station with 30 feet of conduit and wiring.
   2. Cost to provide device and complete installation, engineering and drawings, programming and testing for an addressable smoke detector as detailed on the Drawings and Specifications. Unit price per addressable smoke detector with 30 feet of conduit and wiring.
   3. Cost to provide device and complete installation, engineering and drawings, programming and testing for an addressable heat detector as detailed on the Drawings and Specifications. Unit price per addressable heat detector with 30 feet of conduit and wiring.
   4. Cost to provide device and complete installation, engineering and drawings, programming, and testing for an addressable duct detector with remote test/reset switch as detailed on the Drawings and Specifications. Unit price per addressable duct detector with 30 feet of conduit and wiring.
   5. Cost to provide device and complete installation, engineering and drawings, programming and testing for an addressable monitor module as detailed on the Drawings and Specifications. Unit price per addressable interface module with 30 feet of conduit and wiring.

6. Cost to provide device and complete installation, engineering and drawings, programming and testing for an addressable control module as detailed on the Drawings and Specifications. Unit price per addressable interface module with 30 feet of conduit and wiring.
7. Cost to provide device and complete installation, engineering and drawings, programming and testing for a strobe as detailed on the Drawings and Specifications. Unit price per strobe with 30 feet of conduit and wiring.
8. Cost to provide device and complete installation, engineering and drawings, programming and testing for a horn/strobe as detailed on the Drawings and Specifications. Unit price per horn/strobe with 30 feet of conduit and wiring.
9. Cost to provide device and complete installation, engineering and drawings, programming and testing for a magnetic door holder as detailed on the Drawings and Specifications. Unit price per magnetic door holder with 30 feet of conduit and wiring.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to project site in original, unopened packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, and shelf life if applicable.

B. Store materials inside, under cover, above ground, and kept dry and protected from physical damage until ready for use. Remove from site and discard wet or damaged materials.

## 1.8 PROJECT CONDITIONS

A. Installed products or materials shall be free from any damage including, but not limited to, physical insult, dirt and debris, moisture, and mold damage.

B. Environmental Limitations: Do not deliver or install products or materials until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

## 1.9 WARRANTY

A. Contractor shall warrant the completed fire alarm system wiring and equipment to be free from inherent defects for a period of one (1) year after system acceptance. The Owner shall determine the date of acceptance. The acceptance date shall not come before substantial completion of the system. The acceptance date shall not come before the system has been completely tested and certified.

B. The Owner reserves the right to make changes to the fire alarm system during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any such changes made by Owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the fire alarm system.

C. Contractor shall have readily available all replacement components necessary for emergency warranty repairs. Contractor shall provide a site specific list of service repair part numbers for system components. Standard manufacturer's service repair parts list is not acceptable. The exact parts used on site shall be listed with the correct service repair part numbers.

D. Contractor shall provide written documentation of all warranty service to the Owner. Documentation shall include a description of repairs, any component replaced and the cause of any component failure.

E. Contractor shall maintain a record of warranty repairs on Site. The specific location shall be the monitoring services location.

F. In the last month of the Warranty Period, all System software and firmware, software, drivers, etc. will be upgraded to the latest release (version) in effect at the end of the Warranty Period. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

G. At any time during the Warranty Period that Contractor is on Site for maintenance, emergency, or normal service, Contractor shall notify the Owner. Contractor shall notify the Owner of all work anticipated being involved for the service work. In addition, no work affecting system operation shall commence until express permission is granted. After the work is completed a work order ticket describing in detail all work performed (i.e. hardware replaced or serviced, software or firmware modifications made, etc.), hours worked, follow-up work required, etc., must be signed by the Owner. Service tickets shall include an explanation of the cause of any component failure.

## 1.10 MAINTENANCE CONTRACT

A. The equipment manufacturer shall make available to the Owner a maintenance contract proposal to provide a minimum of two (2) inspections and tests per year in compliance with NFPA-72 guidelines.

B. Repair service shall be provided 24 (twenty-four) hours per day. Request for routine service and /or repairs shall be responded to within six (6) hours. Emergency request for service and/or repairs shall be responded to within six (6) hours.

C. For emergency repairs outside of the contractors normal working hours the Owner shall be charged only for the after hours premium, not for the base hourly rate.

D. The cost associated with the maintenance contract shall not be included in the project bid. The Owner will enter into a contract directly with the vendor.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Johnson Control Autocall

2.2 SYSTEM CONTROL PANEL

A. Provide a Fire Alarm System panel with the following:
   1. Enclosure: The system enclosure shall be sized to carry all the modules required to meet the specification requirements. Enclosure color shall be red.
   2. Power Supply: The power supply shall be adequate to provide power for the system needs with a minimum rated output of four (4) amps.
   3. Battery/Charger: The battery charger shall be capable of charging up to 25 Ah sealed lead-acid batteries. Batteries shall be mounted within the fire alarm cabinet. Notify Engineer if required battery capacity exceeds cabinet mounting capacity and an external charger/cabinet assembly is required.
   4. Signal Line Circuit(s): Communications for up to two hundred and fifty (250) addressable devices.
   5. Notification Appliance Circuits: Four (4) NAC circuits in Class B wiring configuration.
   6. Auxiliary Output Circuits:
      a. Two (2) Form “C” dry contacts, each rated 2A at 24 VDC.
      b. One (1) relay rated 0.5A at 120 VAC.
   7. Remote annunciator/control panel outputs.
   8. DACT capable of sending point or zone information to a central station depending on protocol required by the central station.

B. Programming
   1. Fully field programmable from the local display or by a PC configuration tool, with Windows-based software for ease of configuration.
   2. Auto configuration, allowing initiating devices to be supervised and send alarm signals to the control panel.
   3. Capable of being programmed for cross-zone initiating device operation.

C. Display: Backlit LCD (minimum 80 characters) or color touch-screen display.

D. Function Switches:
   1. Provide the following switches in addition to any other switches required for the system (switches may be either a mechanical or electrical device/button):
      a. Remote Alarm Transmission By-pass Switch: Shall prevent transmission of all signals to the main fire alarm control unit when in the "off" position. A system trouble signal shall be energized when switch is in the off position.
      b. Alarm Silence Switch: Shall disconnect power to alarm notification circuits on the local building alarm system. A system trouble signal shall be activated when switch is in the off position.
      c. Alarm Acknowledge Switch: Shall silence the alarm signal whenever the trouble acknowledge switch is operated. This switch shall not reset the alarm signal.

d. Supervisory Acknowledge Switch: Shall silence the alarm signal whenever the supervisory acknowledge switch is operated. This switch shall not reset the supervisory signal.
e. Trouble Acknowledge Switch: Shall silence the trouble signal whenever the trouble acknowledge switch is operated. This switch shall not reset the trouble signal.
f. Reset Switch: Shall reset the system after an alarm, provided the initiating device has been reset. The system shall lock in alarm until reset.
g. Lamp Test Switch: A test switch or other approved convenient means shall be provided to test the indicator lamps.
h. Drill Switch: Shall activate all notification devices without tripping the remote alarm transmitter. This switch is required only for general evacuation systems specified herein.
i. Door Holder By-Pass Switch: Shall prevent doors from releasing during fire alarm tests. A system trouble alarm shall be energized when switch is in the abnormal position.
j. Elevator recall By-Pass Switch: Shall prevent the elevators from recalling upon operation of any of the devices installed to perform that function. A system trouble alarm shall be energized when the switch is in the abnormal position.
k. HVAC/Smoke Damper By-Pass: Provide a means to disable HVAC fans from shutting down and/or smoke dampers from closing upon operation of an initiating device designed to interconnect with these devices.

E. Cellular Fire Alarm Communicator
1. Provide a UL-listed cellular fire alarm communicator compatible with the fire alarm control panel and listed for fire alarm signaling service. The communicator shall transmit alarm, supervisory, and trouble signals to the monitoring service designated by the Owner. Install the communicator adjacent to the fire alarm control panel unless otherwise recommended by the manufacturer.
2. Provide three (3) addressable relays at the communicator location as follows:
   a. a. One (1) relay activated upon a fire alarm condition.
   b. b. One (1) relay activated upon a system trouble condition.
   c. c. One (1) relay activated upon a supervisory condition.
3. Permanently label each relay according to its function. Relays shall be controlled by the fire alarm control panel and connected through supervised signaling circuits. Each relay shall include an LED indicator that visibly indicates its activated state without removing the cover or disassembling the relay or enclosure.
4. The communicator shall transmit signals through a commercial cellular network approved by the monitoring service. Coordinate the cellular service provider, communication format, monitoring account, programming requirements, and central-station compatibility with the Owner and monitoring service.
5. Provide all antennas, remote antenna extension kits, power supplies, standby batteries, surge-protection devices, mounting hardware, wiring, programming, licenses, and accessories required for a complete and operational system.
6. Verify adequate cellular signal strength at the communicator location before installation. Where signal strength is inadequate, provide a remote antenna, antenna extension kit, or other manufacturer-approved equipment necessary to establish reliable communication.

7. Loss of the cellular communication path shall initiate a trouble signal at the fire alarm control panel and shall be reported in accordance with NFPA 72 and the requirements of the monitoring service.
8. Coordinate activation, programming, testing, and commissioning of the communicator with the Owner, fire alarm system manufacturer, and monitoring service. Demonstrate successful transmission and receipt of alarm, supervisory, and trouble signals before final acceptance.
9. The Contractor shall include all costs associated with installation, activation, programming, testing, and commissioning. Recurring cellular and monitoring-service fees after final acceptance shall be paid by the Owner unless indicated otherwise in the Contract Documents.
10. Three (3) relays shall be provided at the dialer location, one (1) to activate upon alarm, one (1) to activate upon a system trouble condition and one (1) to activate upon a supervisory condition. The relays shall be permanently labeled as to their function. The relays shall be controlled from the fire alarm control panel and connected to the panel via supervised signaling circuits. Wherever relays are used the relay shall include an LED indicator which indicates the activated state of the relay. The LED indicator shall allow for visual verification of relay activation without disassembly of the relay or the relay enclosure.
11. The dialer shall be connected to the public switched telephone network upstream of any private telephone system at the protected premises. Two (2) telephone lines, a primary line and a secondary line, shall be provided for the dialer. The telephone lines shall be terminated at the dialer location using RJ31X style jacks.

F. Testing
1. Walk test by a single individual in either a silent or audible mode.
2. Maintenance and Technician access levels with password protection.

G. Interfacing
1. A history log with a minimum of 2000 stored events shall be provided.
2. An interface for a printer or computer shall be provided to allow for down loading of the history log or system configuration download/upload.

H. Approvals: The system shall be UL and ULC listed, FM approved.

I. Response Time: The system response time from alarm to output shall not exceed four (4) seconds.

## 2.3 REMOTE ANNUNCIATOR

A. Provide and install LCD annunciators as indicated on the Drawings.

B. Shall be a supervised, LCD display containing a minimum of two lines of 40 characters for alarm annunciation in clear English text.

C. Message shall identify building number, floor, zone, etc on the first line and device description and status (pull station, smoke detector, waterflow alarm or trouble condition) on the second line.

D. The initial alarm received shall be indicated as such.

E. A selector switch shall be provided for viewing subsequent alarm messages.

F. The display shall be UL listed for fire alarm application.

G. Coordinate exact locations for LCD annunciators with Owner and the Fire Department.

## 2.4 INTELLIGENT INITIATING DEVICES

A. The detector shall have an LED indicating detector status and alarm.
   1. Where required, there shall be available a programmable remote lamp configurable to remotely duplicate the on-board LED status of another system device with the same software address.

B. Combination Detector:
   1. The intelligent combination fire detector shall be comprised of four sensing elements, including a photoelectric (light-scattering) particulate sensor, an electrochemical carbon monoxide (CO) sensor, a daylight-filtered infrared sensor and solid state thermal sensor(s) rated at 135°F (57.2°C). The device shall be able to indicate distinct smoke and heat alarms. The intelligent multi-criteria detection device shall include the ability to combine the signal of the photoelectric signal with other sensing elements in an effort to react quickly in the event of a fire situation.
   2. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within five (5) seconds. So as to minimize the effort required by the installing and maintenance technician to appropriately configure the detector to ensure optimal system design, the detectors shall be programmable as application specific. Application settings shall be selected in software for a minimum of eleven environmental fire profiles unique to the devices installed location.
   3. The detector shall be designed to reduce the possibility of false indications caused by dust, moisture, RFI/EMI, chemical fumes and air movement while factoring in conditions of ambient temperature rise, obscuration rate changes and hot/cold smoke phenomenon into the alarm decision to give the earliest possible real alarm condition report.
   4. The detector shall support the use of a relay, or LED remote indicator without requiring an additional software address. Detector wiring shall not require any special shielded cable. For the detector where required, there shall be available a locking kit and detector guard to prevent unauthorized detector removal.

C. Optical Smoke Detector
   1. The optical smoke detector shall be an intelligent digital photoelectric detector. Detectors shall be listed for use as open area protective coverage, in duct installation and sampling assembly installation and shall be insensitive to air velocity changes.
   2. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within four (4) seconds.
   3. The detector shall be designed to reduce the possibility of false indications caused by dust, moisture, RFI/EMI, chemical fumes and air movement while factoring in conditions of ambient temperature rise, obscuration rate changes and hot/cold smoke phenomenon into the alarm decision to give the earliest possible real alarm condition report.

4. The detector shall support the use of a relay, or LED remote indicator without requiring an additional software address. Detector wiring shall not require any special shielded cable. For the detector, where required, there shall be available a locking kit and detector guard to prevent unauthorized detector removal.

D. Thermal Detectors
   1. Thermal Detectors shall be rated at 135° F fixed temperature and 15° F per minute rate of rise. Detectors shall be constructed to compensate for the thermal lag inherent in conventional type detectors due to the thermal mass, and alarm at the set point of 135°F.
   2. The choice of alarm reporting as a fixed temperature detector or a combination of fixed and rate of rise shall be made in system software and be changeable at any time without the necessity of hardware replacement.
   3. The detectors furnished shall have a listed spacing for coverage up to 2,500 square feet and shall be installed according to the requirements of NFPA 72 for open area coverage.

E. Duct Detectors
   1. For duct detector applications, the smoke detector shall be an intelligent digital photoelectric detector with a programmable heat detector or a digital photoelectric detector.
   2. Detectors shall be listed for use as open area protective coverage, in duct installation and sampling assembly installation and shall be insensitive to air velocity changes.
   3. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within four (4) seconds.
   4. The detector shall be mounted in a duct detector housing listed for that purpose. The duct detector shall support the use of a remote test switch, relay or LED remote indicator. The duct detector shall be supplied with the appropriate sampling tubes to fit the installation. Where duct detectors are exposed to the weather, a weatherproof enclosure shall be available. The duct housing cover shall include a test port for functional testing of the detector without cover removal. The duct housing shall include a cover removal switch capable of indicating cover removal status to the fire alarm control panel.
   5. Where required there shall be available a duct housing with an on-board relay. Also where required, there shall be a standalone housing available with it’s own power supply and test/reset switch that does not require connection to a fire alarm control panel.

F. Detector bases shall be low profile twist lock type with screw clamp terminals and self-wiping contacts. Bases shall be installed on an industry standard, 4" square or octagonal electrical outlet box.
   1. Where selective localized control of electrical devices is required for system operation, furnish and install detector base with software programmed addressable relay integral to the base. The relay shall switch electrical loads within relay ratings, as indicated on the drawings. Operation of the addressable control circuit shall be independent of the number of detectors and relays on the circuit or the number in an alarm state. Relay bases shall be rated for resistive or inductive load (120VAC or 30VDC) 3 amps.
   2. Where indicated on the drawings, furnish detector base with integral approved audible evacuation alarm signal having an output of 85db @ 10’. The audible signal shall be individually addressable and software programmed for operation.

G. Provide addressable manual stations where shown on the drawings, to be flush or surface mounted as required. Manual stations shall contain the intelligence for reporting address,

identity, alarm and trouble to the fire alarm control panel. The manual station communications shall allow the station to provide alarm input to the system and alarm output from the system within less than four (4) seconds. The manual station shall be equipped with terminal strip and pressure style screw terminals for the connection of field wiring. Surface mounted stations where indicated on the drawings shall be mounted using a manufacturer's prescribed matching red enamel outlet box.

1. Where required, there shall also be available pull stations with break glass, capable of explosion proof installation, capable of weatherproof installation, two (2) stage operation, reset key operation, and metal housings.

H. Addressable Monitor Modules shall be provided to monitor contacts for such items as water-flow, tamper, and PIV switches connected to the fire alarm system. These modules shall be able to monitor a single or dual contact. An address will be provided for each contact. Where remote supervised relay is required the interface shall be equipped with a SPDT relay rated for 4 amps resistive and 3.5 amps inductive.

I. Where needed, a Conventional Zone Module shall connect to the Signal Line Circuit, which will allow the use of conventional initiation devices. This module shall have the ability to support up to 15 convention smoke detectors and an unlimited number of contact devices. This module shall also be capable of monitoring beam detectors and conventional flame detectors. Where required, there shall be an intrinsically safe detection solution for NEMA defined intrinsically safe installations compatible with the conventional zone module.

## 2.5 NOTIFICATION APPLIANCES

A. Horn and Horn Strobe Appliances
   1. Horn strobe and standalone horn appliances shall meet and be listed for:
      a. UL Standard 1971 (Emergency Devices for the Hearing-Impaired for Indoor Fire Protection Service).
      b. Standard 464 (Fire Protective Signaling).
      c. Horn strobe shall be listed for indoor use and shall meet the requirement of FCC Part 15 - Class B.
   2. All inputs shall be compatible with standard reverse polarity supervision of circuit wiring by the Fire Alarm Control Panel (FACP).
   3. Audible portion of the appliance shall have a minimum of two (2) field-selectable settings for dBA levels, and shall have a choice of continuous or temporal (Code 3) audible output.
   4. Horns shall be of low-current design.
   5. Housing shall be red with white lettering except where white is used to match existing devices.
   6. Strobe portion of the appliance shall produce a flash rate of one (1) flash per second over the regulated input voltage range, and shall incorporate a Xenon flashtube or LED source enclosed in a rugged Lexan® lens.
   7. Strobe intensity, where multi-candela appliances are specified, shall have field-selectable settings, and shall be rated per UL Standard 1971 for:
      a. 15/30/75/110cd.
      b. 135/185cd.

8. The selector switch for selecting the candela setting shall be tamper resistant and not accessible from the front of the appliance.
9. All notification appliances shall listed for Special Applications.

B. Strobes
1. Strobes shall meet and be listed for UL Standard 1971 (Emergency Devices for the Hearing-Impaired) for Indoor Fire Protection Service.
2. Strobe shall be listed for indoor use, and shall meet the requirements of FCC Part 15 Class B.
3. Strobe appliances shall produce a flash rate of one (1) flash per second over the regulated voltage range, and shall incorporate a Xenon flashtube or LED source enclosed in a rugged Lexan® lens.
4. All inputs shall be compatible with standard, reverse polarity supervision of circuit wiring by a Fire-Alarm Control Panel (FACP).
5. Strobes shall be of low-current design.
6. Housing shall be red with white lettering except where white is used to match existing devices.
7. Where multi-candela strobes are specified, the strobe intensity shall have field-selectable settings and shall be rated per UL Standard 1971 at:
   a. 15/30/75/110cd for wall mount
   b. 15/30/75/95cd or 115/177cd for ceiling mount
   c. The selector switch for selecting the candela shall be tamper resistant and not accessible from the front of the appliance.
8. The strobes shall be designed for indoor surface of flush mounting

C. Sprinkler Horn/Strobe
1. Locate this device directly above the fire department sprinkler connection on the exterior of the building.
2. Sprinkler horn/strobe circuits shall be home run to the FACP for power.
3. Sprinkler horn/strobe control module should be located inside the building near the penetration. Do not use FACP signal output.

D. Synchronization
1. Where multiple strobes are installed in a common space, the strobes shall be synchronized.
2. The strobes shall not drift out of synchronization at any time during operation.
3. Audibles and strobes shall be able to synchronize on a two (2)-wire circuit with the capability to silence the audible, if required.
4. Strobes shall revert to a non-synchronized flash-rate, if the sync module or power supply should fail to operate (i.e. – contacts remain closed).

## 2.6 GUARDS FOR PHYSICAL PROTECTION

A. Welded wire mesh of size and shape for the manual station, smoke detector, notification device, or other device requiring protection. Install where noted on the Drawings.

B. Factory fabricated and furnished by the manufacturer of the device.

C. White epoxy powder coat finish.

## 2.7 MAGNETIC DOOR HOLDERS

A. Magnetic door holders shall have an approximate holding force of 35 lbs.

B. Magnetic door holder back boxes shall be mounted to building structure.

C. Retrofit boxes or other boxes mounted to sheetrock only shall not be acceptable.

D. The door portion shall have a stainless steel pivotal mounted armature with shock absorbing nylon bearing.

E. Unit shall be capable of surface, flush, semi-flush or floor mounting as required.

F. Magnetic door holders shall be 120 VAC powered from a dedicated circuit, 24 VDC and powered from a dedicated power supply at the fire alarm control panel, or a dedicated NAC power supply at a designated remote location. The dedicated power supplies shall not share power with notification devices.

G. When magnetic door holders are added to an existing system the submittal shall include a power availability analysis showing the intended source of power, the door holder circuit capacity and standby power capacity.

H. Magnetic door holders shall be installed at a height of 86 inches or less from the finished floor to the center of the back box.

I. Magnetic door holders shall be UL-Listed for their intended purpose.

J. Magnetic door holder operation shall be independent from another operation such as damper or fire shutter control or electric door control.

K. Coordinate mounting with door hardware.

## 2.8 INSTRUCTION CHART

A. Provide typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame with a backplate. Install the frame adjacent to the control unit and where operations are performed. The card shall show those steps to be taken by an operator when a signal is received under all conditions, normal, alarm, supervisory, and trouble. Provide an additional copy with the binder for the input output matrix for the sequence of operation. The instructions shall be approved by the Owner before being posted.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall be in accordance with NFPA 70, 72, 90A, and 101 as shown on the drawings, and as recommended by the major equipment manufacturer.

B. All fire detection and alarm system devices, control units and remote annunciators shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.

C. Location of all controls, alarm actuating devices and audible alarm signaling devices shall generally be as shown on the Drawings. In areas where there are no ceilings, install detectors against the building structure in accordance with manufacturer recommendations. In finished areas, devices shall be located in a symmetrical pattern relating to ceiling and/or wall features and, where applicable, ceiling mounted devices shall be located symmetrically with the ceiling grid centered in two directions. Vertically align pull stations and audible/visual alarm signaling devices where possible. Where audio/visual, audio only or visual only devices are surface mounted to surface mounted junction boxes, install the manufacturer's skirt, which is designed to enhance aesthetics.

D. Strobes shall be flush wall mounted 80 inches above the floor or 6 inches below ceiling, whichever is lower. Locate and mount to maintain a minimum 36 inches clearance from side obstructions

E. Manual pull stations shall be installed not less than 42 inches or more than 48 inches from finished floor to bottom of device and within 60 inches of a stairway or an exit door.

F. The fire alarm panel shall be programmed with a specific description for each device, including device type, room name, and room number using the Owner's final room numbering scheme, which may differ from the architectural plans. For expansion and/or revisions to existing systems, coordinate final programming and descriptions with the Owner.

3.2 BOXES AND ENCLOSURES

A. Boxes shall be installed plumb and firmly in position.

B. Wherever splices are made in J-boxes, wires shall be labeled with the system circuit number and area served. Wire tags shall be affixed to identify the wires. Writing on wires with a marking pen shall not be an acceptable means of wire identification.

C. J-box covers shall be painted red and clearly marked "Fire Alarm".

## 3.3 CONDUCTORS

A. All wiring shall be installed in conduit where concealed behind walls and inaccessible ceilings. Wiring above accessible ceilings may be run exposed.

B. Where a building's fire alarm system is being added to or modified, the wiring method shall match the building's predominant existing wiring method

C. Each conductor shall be identified as shown on the shop drawings with wire markers at terminal points. Attach permanent wire markers within 2 inches of wire termination. Marker legends shall be visible.

D. All wiring shall be supplied and installed in compliance with the requirements of the National Electric Code, NFPA 70, Article 760, and that of the manufacturer.

E. Where fire alarm system wiring is installed exposed, the wiring shall be installed in such a way that maximum protection from physical damage is provided.

F. Provide bushings, connectors, strain relief devices, boxes and covers specifically designed for structured cabling use.

G. Bushings and throats shall be installed for fittings, raceways, boxes or other enclosures prior to installing cables and wiring systems.

H. Wiring for notification appliance circuits shall be a minimum 14 AWG. Wiring for signaling line circuits shall be a minimum 18 AWG.

I. All splices shall be made using solderless connectors. All connectors shall be installed in conformance with manufacturer recommendations.

J. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.

K. A consistent color code shall be used for conductors throughout the installation. The installation contractor shall submit for approval, prior to installation of wire, a proposed color code for system conductors to allow rapid identification of circuit types.

## 3.4 FIRE PROTECTION SYSTEM CONNECTIONS

A. Each sprinkler system water supply control valve, riser valve or zone control valve, and each standpipe system riser control valve shall be equipped with a supervisory switch. Standpipe hose valves, and test and drain valves shall not be equipped with supervisory switches.

B. Where possible, locate water flow and pressure switches a minimum of 12 inches from a fitting that changes the direction of the flow and a minimum of 36 inches from a valve.

C. Mount valve tamper switches so as not to interfere with the normal operation of the valve and adjust to operate within 2 revolutions toward the closed position of the valve control, or when the stem has moved no more than 1/5 of the distance from its normal position.

D. PIV (post indicator valve) or main gate valve shall be equipped with a supervisory switch.

E. Valve supervisory switches, furnished and installed under Division 23, shall be connected to the fire alarm system by way of addressable monitor module. Provide one (1) module for a group of tamper switches in a common room unless specified otherwise on the Drawings.

F. Wet pipe water flow switches and dry pipe alarm pressure switches for sprinkler systems shall be connected to the fire alarm system by way of an addressable monitor module. Provide one module for each flow and pressure switch.

G. Where dry-pipe sprinkler systems are installed, high and low air pressure switches shall be provided and monitored by way of addressable monitor modules. Provide one module for each sensor/alarm.

## 3.5 ELEVATOR CONNECTIONS

A. Elevator Recall
   1. When appropriate alarms are reported, control points tied to the elevator control circuitry will energize and the elevators will be recalled to the primary floor for fire fighter's use. If the initiating device is on the primary floor, the elevators will be sent to the predestinated alternate floor. This is accomplished by providing three (3) addressable control modules at the elevator controller(s).
   2. The Contractor shall provide all necessary cables and wire for elevator recall, including wiring to elevator car/controller.
   3. The Contractor shall install the elevator recall, alternate recall and elevator signal relays adjacent to the elevator wire gutter in the respective elevator machine room.
   4. Smoke detectors in the elevator lobby, machine room, and elevator shaft shall be installed to initiate elevator recall.
   5. Lobby smoke detectors shall be located on the ceiling within 21 feet of the centerline of each elevator door within the elevator bank under control of the detectors.

B. Elevator Power Shunt Trip
   1. When a building is equipped with an automatic sprinkler system and an elevator, the power to the elevator shall be disconnected prior to the activation of a sprinkler head in the elevator machine room, hoistway, or pit.
   2. 135°F heat detectors shall be installed in the elevator machine room, hoistway, and pit within 24" of each sprinkler head.

## 3.6 SYSTEM OPERATION

A. Refer to the fire alarm operation matrix on the Drawings. Additional information is noted below.

B. Activation of any manual pull station, water flow or pressure switch, heat detector, kitchen hood suppression system, gaseous suppression system, or smoke detector shall cause the following operations to occur:
   1. For sprinkler protected buildings, flash strobes continuously only in the zone of alarm. For buildings without sprinkler protection throughout, flash strobes continuously only on the floor of alarm.
   2. Continuously sound a temporal pattern general alarm and flash all strobes in the building until reset at the fire alarm control panel.
   3. Release all magnetic door holders in the smoke zone after the alert signal.
   4. Transmit a separate alarm signal, via the main fire alarm control unit to the fire department.
   5. Unlock the electrically locked exit doors within the zone of alarm.

C. Heat detectors in elevator machine rooms shall, in addition to the above functions, disconnect all power to all elevators served by that machine room after a time delay. The time delay shall be programmed within the fire alarm system programming and be equal to the time it takes for the car to travel from the highest to the lowest level, plus 10 seconds.

D. Smoke detectors in the primary elevator lobbies shall, in addition to the above functions, return all elevators in the bank to the secondary floor.

E. Smoke detectors in the remaining elevator lobbies, elevator machine room, or top of hoistway shall, in addition to the above functions, return all elevators in the bank to the primary floor.

F. Operation of a smoke detector at a corridor door used for automatic closing shall release all magnetic door holders in that smoke zone.

G. Operation of a smoke detector at a smoke shutter used for automatic closing shall release only the shutters in that smoke zone.

H. Operation of duct smoke detectors shall cause a system supervisory condition and shut down the ventilation system and close the associated smoke dampers as appropriate.

I. Operation of any sprinkler or standpipe system valve supervisory switch, high/low air pressure switch, or fire pump alarm switch shall cause a system supervisory condition.

## 3.7 FIELD QUALITY CONTROL

A. All installation and acceptance inspections shall be performed by a licensed fire alarm technician or planner and be documented on the inspection form.

B. It is the Contractor’s responsibility to coordinate all testing between trades to ensure all necessary personnel are present and prepared at scheduled tests.

C. The Contractor shall perform all tests required by NFPA, State, and Local codes.

D. The Contractor shall verify that all fire alarm device descriptions programmed into the system use the FINAL room names and numbers as developed by the Owner which may be different that the names and numbers used on the Construction Documents.

E. The Owner and Engineer shall be notified before the start of the required tests. All items found at variance with the applicable Codes, Drawings, or Specifications during testing or inspection by a representative of the Authority Having Jurisdiction shall be corrected by Contractor at no charge or expense to the Owner.

F. When the systems have been completed and prior to the scheduling of the final inspection, furnish testing equipment and perform the following tests. When any defects are detected, make repairs or install replacement components, and repeat the tests until such time that the complete fire alarm system meets all contract requirements. After the system has passed the initial test the contractor may request a final inspection.
   1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
   2. Test the insulation on all installed cable and wiring by standard methods as recommended by the equipment manufacturer.
   3. Run water through all flow switches. Check time delay on water flow switches. Submit a report listing all water flow switch operations and their retard time in seconds.
   4. Open each alarm initiating and notification circuit to see if trouble signal actuates.
   5. Ground each alarm initiation and notification circuit and verify response of trouble signals.

G. Test reports shall be delivered to the General Contractor as completed.

## 3.8 TESTING

A. General
   1. A written acceptance test procedure (ATP) for testing the fire detection and control components and installation shall be prepared by the installer and approved by the Engineer in accordance with NFPA 72 and this specification. The contractor shall be responsible for the performance of the ATP, demonstrating the function of the system and verifying the correct operation of all system components, circuits, and programming.
   2. A program matrix shall be prepared by the installing contractor referencing each alarm input to every output function affected as a result of an alarm condition on that input.
   3. The Owner and Engineer shall be notified 10 days before the start of the required tests. All items found at variance with the applicable Codes, Drawings, or Specifications during testing or inspection by a representative of the Authority Having Jurisdiction shall be corrected by the Contractor at no charge or expense to the Owner.
   4. Prior to the acceptance test, the installing contractor shall prepare a complete listing of all device labels for alphanumeric annunciator display.

B. Preliminary Testing
   1. Preliminary testing shall include all testing necessary to certify the correct operation of the entire fire alarm system. The certification of the fire alarm system is required prior to presenting the system for acceptance testing. Preliminary testing shall include as a minimum a pre-functional test, functional performance test and an integrated system test.

It is the contractor's responsibility to schedule, perform and document these tests. A representative from the Owner and Engineer may monitor the preliminary tests but the presence of a representative is not required. No part of the fire alarm system is considered to be accepted at any point prior to the final acceptance test.

2. All intelligent devices shall be tested and logged for correct address and sensitivity using test equipment specifically designed for that purpose.
3. Each notification device shall be individually tested and shall be logged by location. The test report shall include the device type, model number, circuit number, candela or wattage setting, individual device location and test results. For each device a passing note shall indicate the device meets all codes, specifications and manufacturer's recommendations regarding placement, performance and workmanship
4. Wiring runs shall be tested for continuity, short circuits and grounds before system is energized. Resistance, current and voltage readings shall be made as work progresses.
5. Preliminary testing as required by code and state laws shall be performed and properly documented at the appropriate times during the installation process.
6. On larger projects, multiple preliminary tests shall be performed as each portion of work completed dictates. All preliminary tests shall be completed prior to presenting the fire alarm system for acceptance testing.
7. Documentation of the preliminary testing shall be retained by the certifying company and presented at the acceptance test as part of the project documentation package.

C. Acceptance Testing
1. The acceptance inspector shall use the system record drawings in combination with the documents specified in this Specification during the testing procedure to verify operation as programmed. In conducting the acceptance test, the acceptance inspector shall request demonstration of any or all input and output functions. The items tested shall include but not be limited to the following:
    a. A systematic inspection of all system equipment and components to ensure compliance with these specifications.
    b. A comprehensive test of all peripheral devices.
    c. Testing of all network annunciators to ensure correct display of points.
    d. Manual pull stations shall be tested by pulling the handle and reset with key. The break rod shall be installed at the time the manual pull station has passed the acceptance test. The keys for each manual pull station shall be delivered to the Owner's representative at the time of the acceptance test.
    e. Smoke detectors shall be tested using smoke detector test smoke approved for that purpose.
    f. Each visual notification device shall be checked for correct candela settings. Correct operation and jumper settings of each notification devices shall be verified and listed individually in the inspection report.
    g. The system shall be tested in full general alarm mode for a minimum of 10 minutes.
    h. A complete test of all system functions and controls.

2. In addition to the basic system functions, acceptance testing shall include but not be limited to the following systems as appropriate.
    a. Elevator recall.
    b. Elevator shunt trip.
    c. AHU shutdown.

d. Sprinkler system monitoring modules.
e. Smoke damper operation.
f. Fire/smoke shutter operation.

3. Secondary power capabilities shall be demonstrated as follows:
   a. System primary power shall be disconnected for a period of seven (7) hours. At the end of that period, an alarm condition shall be created and the system shall perform as specified for a period of five (5) minutes.
   b. System primary power shall be restored for 48 hours and system- charging current shall be normal trickle charge for a fully charged battery pack.
   c. System battery voltages and charging currents shall be checked at the fire alarm control panel using the test codes and displayed on the LCD display.

4. Fireman's HVAC override system functions shall be demonstrated as follows:
   a. On/off control of each controlled element and test for interaction of other automatic and manual control functions while in the override mode.
   b. Correct status display of monitored elements.
   c. Correct logging of activity to printer and historical memory as programmed.
   d. Contractor shall provide skilled technicians to execute testing. Ensure that they are available and present during the agreed-upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.
5. Correct message display, building, room number, and icon location for each alarm input at the control panel, each remote annunciator display and at the voice control panel.
6. System wiring shall be tested to demonstrate correct system response and correct subsequent system operation in the event of:
   a. Open, shorted and grounded signal line circuits.
   b. Open, shorted and grounded notification and releasing circuits.
   c. Primary power or battery disconnected.

## 3.9 DOCUMENTATION

A. System documentation shall be furnished to the Owner and shall include but not be limited to the following:
   1. System record drawings with wiring details including one set of reproducible masters and drawings on a CD ROM in a DXF format suitable for use in a CAD drafting program.
   2. Electronic copy of the system operation, installation and maintenance manual.
   3. System matrix showing interaction of all input signals with output commands.
   4. Documentation of system voltage, current and resistance readings taken during the installation and testing phases of the system installation.
   5. System program showing system functions, controls and labeling of equipment and devices.

## 3.10 SERVICE CONTRACT

A. The Contractor or manufacturer shall offer for the Owner's consideration at the time of system submittal a priced inspection, maintenance, testing and repair contract in full compliance with

the requirements of NFPA. The Owner shall have the option of renewing at the price quoted for single or multiple years up to five (5) years. The contract shall include, at a minimum:

1. A semi-annual configuration audit and report.
2. Complete semi-annual test and inspection, including but not limited to:
    a. Verification of agent storage container pressure.
    b. Verification of agent weight in each agent storage container, either by weighing or through the use of integral liquid level indicator(s). External ultrasonic liquid level measurement devices shall not be used.
    c. Operation of each initiating device, with verification of proper response.
    d. Verification of the complete system sequence of operation, not including shutdown of critical equipment.
    e. Verification of proper operation of all indicating devices and signals.
3. Cleaning and sensitivity verification of all smoke detectors. All smoke detectors that do not meet sensitivity verification or do not perform as required in testing shall be exchanged at no additional charge.
4. System firmware and software upgrades for the fire alarm control panel, as required to maintain the listing requirement of the authority having jurisdiction.
5. Under this service contract, trained technicians shall perform inspections and diagnostic tests of panel functions, auxiliary and monitoring functions, and all accessible peripheral devices listed and currently connected to the facility Life Safety System (Fire Alarm System). Tests will be scheduled in advance, and at the convenience of the Owner's schedule.
6. Up to four (4) hours of annual training for the Owner's staff.
7. There shall be no minimum billing for service calls not covered under the Contract. Only actual time for service shall be billed.
8. Emergency service personnel shall be available 24 hours per day, 7 days per week, 365 days per year, to respond to any emergency request.
9. All accessible components and devices shall be logged for:
    a. Test results and applicable voltage readings.
    b. Any discrepancies found shall be noted individually and on a separate summary page.
    c. NFPA 72 approved documentation.
10. A log book shall be provided. All inspection, testing, service, and maintenance shall be logged by the performing contractor. All documentation associated with the inspection shall be provided to the Owner with three (3) business days of the inspection. Documentation shall include, but not limited to, the following:
    a. Name of the activity.
    b. Date of the activity.
    c. Required frequency of the activity.
    d. Name and contact information, including affiliation, of the person who performed the activity.
    e. NFPA standard(s) referenced for the activity.
    f. Results of the activity.

## 3.11 TRAINING

A. Formal training for the operation and maintenance of all fire alarm equipment and the systems specified herein shall be given by factory trained and certified personnel.

B. The training shall not take place until all system devices, annunciators and controls have been installed and certified operational by the licensed fire alarm technician. The certifying technician shall be present throughout the training sessions.

C. The Contractor and/or the Systems Manufacturer's representative shall provide a typewritten "Sequence of Operation" including a trouble shooting guide of the entire system. The sequence of operation will be shown for each input in the system in a matrix format and provided in a loose leaf binder. When reading the sequence of operation, the reader will be able to quickly and easily determine what output will occur upon activation of any input in the system. The INPUT/OUTPUT matrix format shall be as shown in Appendix A to NFPA 72.

D. The installation contractor shall furnish training as follows for a minimum of four employees of the system user:
   1. Training in the receipt, handling and acknowledgment of alarms.
   2. Training in the system operation including manual control of output functions from the system control panel.
   3. Training in the testing of the system including logging of detector sensitivity, field test of devices and response to common troubles.
   4. The total training requirement shall be a minimum of two (2) hours, but shall be sufficient to cover all items specified.

**END OF SECTION**

**ATTACHMENT "A" PRERECORDED VOICE MESSAGES TEXT**

**ALL CLEAR**

Attention, may I have your attention please.
The fire alarm condition has been cleared.
I repeat.
The fire alarm condition has been cleared.
All systems have been returned to normal.
Thank you for your co-operation.

**ALL CLEAR IN SPANISH**

Su atencion, por favor
El estado de alerta de fuego ha sido resuelto.
Repito
El estado de alerta de fuego ha sido resuelto.
Todos los sistemas se han normalizado.
Gracias por su cooperacion

**TESTING**

Attention, may I have your attention please.
We are conducting a test of the life safety system.
Please disregard the audio signals and flashing lights, as they are only a test.
Thank you.

**TESTING IN SPANISH**

Su atencion, por favor.
Estamos conduciendo una prueba del sistema de seguridad.
Por favor, ignore las senales de audio y las luces intermitentes, porque son solo una prueba.
Gracias

**TESTING COMPLETED**

Attention, may I have your attention please.
We have completed our test of the life safety system.
All systems have been returned to normal.
Thank you for your co-operation.

**TESTING COMPLETED IN SPANISH**

Su atencion por favor
Hemos completado nuestra prueba del sistema de seguridad.
Todos los sistemas se han normalizedo.
Repito
Hemos completado nuestra prueba del sistema de seguridad.
Todos los sistemas se han normalizado.
Gracias por su cooperacion.

**DRILL MESSAGE**

Attention, may I have your attention please.
This is a practice fire drill.
Please follow RACE procedures.
Thank you.

**DRILL MESSAGE IN SPANISH**

Su atencion por favor.
Este es un simulacro de incendio.
Por favor, siga los procedimientos de R-A-C-E
Gracias

**DRILL COMPLETED**

Attention, may I have your attention please.
This has been a fire drill.
I repeat
This has been a fire drill.
This is an all-clear notification.
Thank you for your co-operation

**DRILL COMPLETED IN SPANISH**

Su atencion por favor.
Esto ha sido un simulacro de incendio.
Repito.
Esto ha sido un simulacro de incendio.
Esta es la senal de finalizacion del simulacro.
Gracias por su cooperacion.

END OF ATTACHMENT “A” - SECTION 283100

**SECTION 312303**

**EXCAVATING, BACKFILLING AND COMPACTING FOR THE BUILDING PAD**

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

A. Comply with Conditions of the Contract, Division 1 - General Requirements, and referenced documents.

B. Related Work:
   1. Division 1: Testing Laboratory Services.
   2. Division 7: Waterproofing.
   3. Divisions 22, 23 & 26: Furnishing and installing underground mechanical and electrical structures and lines, including excavating, backfilling, and compacting.
   4. Division 31: Earthwork for Sitework.
   5. Section 316329: Drilled Concrete Piers.
   6. Division 31: Sitework Concrete.

C. Obtain copies of the Geotechnical Report for this project and comply with specific recommendations for the selected method of subgrade improvement as described herein.
   1. The subgrade shall be improved to reduce the potential for subgrade movement to on the order of one inch by moisture conditioning two feet of the in-situ soils under footings larger than 3 feet in size and moisture conditioning one foot of in-situ soils for the remainder of the building footprint. Moisture conditioning shall be achieved by excavation and replacement.

1.2 GENERAL DESCRIPTION OF WORK INCLUDED

A. Coordinate work of this Section with work of other sections as required to properly execute work and as necessary to maintain satisfactory progress of work of other Sections.

B. Excavate materials to required subgrades.

C. Removal of existing below grade improvements that occur within excavations.

D. Provide foundation drainage system, if required. Refer to MEP drawings and specifications.

E. Filling, backfilling, compaction, and grading of building pad to required subgrades.

F. Providing off-site suitable fill materials.

G. Dewatering, until permanent drainage system is operational.

H. Disposal of excess and unsuitable excavated materials.

I. Providing adequate dust control measures as necessary to maintain streets in clean condition from excavation site to disposal location.

J. Providing adequate protective measures for public, workmen, adjacent streets, buildings and utilities.

1.3 REFERENCES

A. American Society for Testing and Materials: (Latest Editions)
   1. ASTM C 33, Concrete Aggregates.
   2. ASTM D 698, Moisture-Density Relations of Soils and Soil- Aggregate Mixtures, Using 5.5-lb. (2.5 kg.) Remmer and 12-in. (304.8-mm) Drop.
   3. ASTM D 1556, Density of Soil in Place by the Sand- Cone Method.
   4. ASTM D 2167, Density of Soil in Place by the Rubber-Balloon Method.
   5. ASTM D 2922, Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth.)
   6. ASTM D 3017, Moisture Control of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth.)

1.4 REGULATORY REQUIREMENTS

A. Comply with rules, regulations, laws, and ordinances of authorities having jurisdiction.

B. Notify Department of Public Works - Field Operations, Director of Traffic Control, and Police Department. Make necessary arrangements and obtain their approval of routes used by hauling equipment. Obtain required permits for traffic control during hauling operations.

1.5 QUALITY ASSURANCE

A. Testing Laboratory Services:
   1. The Geotechnical Engineer of Record shall be engaged for quality control testing during fill and backfill operations.
   2. Submit soil materials proposed for backfill to laboratory for testing.
      a. Laboratory will determine suitability of materials to be used.
      b. Laboratory will submit test results and recommendations.
   3. Advise testing laboratory two days in advance of operations.
   4. Tests will be executed immediately prior to covering of such compacted areas.
   5. When tests indicate compaction does not meet requirements, remove fill and backfill completely, dry out or moisten as necessary and recompact.
      a. Retest recompacted areas.
      b. Repeat until tests indicate compliance with specified requirements.
      c. Provide reworking and retesting at no additional compensation.

B. Pre-construction Meeting: The Contractor shall conduct a pre-construction meeting at the site to coordinate earthwork operations. Attendees shall include the Contractor, earthwork sub-contractors, Testing Lab and the Geotechnical Engineer of Record. The meeting agenda will

include a discussion of acceptable materials, moisture conditioning techniques, placement requirements, protection of the excavation, protection of completed work, and testing requirements. Notify the Architect, Engineer and Owner of meeting time (attendance will be at their option).

1.6 SUBMITTALS

A. Product Data: Submit manufacturer's descriptive literature and recommended installation instructions for filter fabric, drainage matting, and vapor retarder.

B. Samples: Submit minimum, 10 lb., samples of each type of fill material to be used. Forward samples to testing laboratory, packed tightly in containers to prevent contamination.

C. Test Reports: If recent test results are available for proposed fill materials, submit to testing laboratory in lieu of samples. Test results are to clearly indicate types of materials and composition, hardness, compactibility and suitability for proposed usage.

D. Laboratory Test Reports for following:
   1. Test reports on borrow material.
   2. Field density reports.
   3. One optimum moisture-maximum density curve for each type soil encountered.
   4. Materials certificate stating materials acceptable for fill and backfill.

1.7 SUBSURFACE INVESTIGATION

A. Owner, Structural Engineer and Architect make no representation regarding character and extent of soil data or other surface or subsurface data and conditions which may be encountered during work and no guarantee as to accuracy or validity of interpretation of such data or conditions is made or intended.

1.8 PROTECTION

A. Provide, erect, and maintain all lights, barricades, warning signs, and guards as necessary.

B. Provide adequate protective measures to protect existing adjacent construction, including buildings, streets, walks, utility lines, the public and workmen.

C. Protect all reference points, benchmarks, and monuments from dislocation or damage, destroyed, or dislocated.

D. Survey adjacent structures and improvements, establishing exact relocations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations. Locate datum level used to establish benchmark elevations sufficiently distant so as not to be affected by movement resulting from excavation operations.

E. During excavation, resurvey benchmarks, employing licensed Land Surveyor or registered Professional Engineer. Maintain accurate log of surveyed elevations for comparison with original elevations.

F. Exercise care during excavations as excessive withdrawal of ground water and lowering of ground water table may adversely affect stability and integrity of existing buildings and structures in vicinity or induce settlement in them through loss of ground (soil or earth), or settlement due to lowering of ground water under them.

G. Damage to buildings, structures, utilities, sidewalks, pavements, and other facilities in vicinity resulting from these operations will be Contractor's responsibility; provide whatever measures as necessary to prevent damages from occurring.

H. Keep adjacent streets and hauling routes free from soils and debris deposited thereon as results of this work. Clean up debris as necessary.

I. Repair or replace work damaged or destroyed while performing work of this Section.

1.9 PROTECTION OF EXCAVATIONS

A. Protect excavations to prevent cave-ins or loose dirt from falling into excavations and to ensure against damage to existing streets, paving, buildings, other structures, and utility lines when excavation and grading work occurs adjacent to or below same.

B. Protect bottoms of excavations and soil around and beneath foundations from frost and water.

C. Grade around excavation to prevent surface water runoff into excavated area.

D. Provide dewatering system as necessary to keep excavations dry at all times until permanent pumping and discharge systems are fully operational.

PART 2 PRODUCTS

2.1 MATERIALS

A. Vapor Retarder: Refer to Section 031000. Provide waterproof tape at all lapped joints and penetrations. See Division 7.

B. Filter Fabric: Permeable polypropylene or polyester construction, not less than 4.0 oz/sq.yd., 140N or 700X Drainage Fabric by Mirafi, Inc., Type T-140-N Stabilenka by American Enka Company, Typar Style 3401 by Dupont, or approved equivalent.

C. Drainage Matting:
1. High-impact polystyrene waffle-like core with filter fabric bonded on one side, and core perforated in areas of foundation weeps; Miradrain by Mirafi Inc., Charlotte, North Carolina, or Eljen Prefabricated Drainage Structures by Ekjen Development Corporation, Storrs, Connecticut.
2. Compression-resistent open nylon matting with filter fabric bonded on one side, Type 9120 Enkadrain by American Enka Company, Enka, North Carolina.

PART 3 EXECUTION

3.1 PREPARATION AND LAYOUT

A. Work shall be laid out by a registered and licensed surveyor. Establish extent of excavation by area and elevation; designate and identify datum elevation. Set required lines and levels.

B. Verify elevations, dimensions, and actual conditions at site. Refer discrepancies to Architect for interpretation or necessary modifications.

C. Maintain benchmarks, monuments, and other reference points.

3.2 UTILITIES

A. Before starting excavation, establish location and extent of underground utilities occurring in work area.

B. Notify utility companies to remove and relocate lines that are in the way of excavation.

C. Remove abandoned utility service lines from areas of excavation; cap, plug or seal such lines and identify at grade.

D. On Project Record Documents accurately locate and record abandoned and active utility lines rerouted and/or extended.

3.3 PUMPING AND DRAINAGE

A. Care shall be taken that no water (from utilities, surface run-off, rainfall, etc.) is allowed to penetrate into the clays beneath the select fill. During construction, provide positive drainage away from the excavation. Install dams, levees, trenches and sumps to divert surface runoff and prevent flooding of the excavation and building pad.

B. Provide adequate provisions for prompt removal of water accumulating in excavations, including temporary sumps, well points, pumps, drain lines, and other equipment or appurtenances as necessary.

C. Keep excavations free from water at all times during excavation and foundation work and prevent water from interfering with progress or quality of work.

D. Drain site to temporary sumps and silt settling basins, and remove accumulated water by pumping to storm sewers. Excavate in sequence that will provide drainage to sumps at all times.

E. When pumping water from excavated areas, take special precautions to avoid undermining of contiguous property by withdrawal of sand, soil, or any other supporting materials from areas below surfaces of such property.

F. Protect leave outs in the floor slab from ponding water by providing protective temporary cover.

G. Do not allow water to flow toward the excavation or building pad along exposed utility trenches by sequencing work to minimize exposure and by providing temporary dams or plugs to block the flow toward the building pad.

3.4 EXCAVATION – GENERAL

A. Excavate subsoil in accordance with lines and levels required for construction of work.

B. Closely coordinate timing of excavation work and provide sufficient working room and surfaces to permit retention system work to be performed in timely and reasonable manner.

C. Coordinate with drilled pier work for special requirements and arrangement regarding excavation to rough out elevations. Coordinate this work with work of Section 316329.

D. Accurately cut excavation to required lines and grade. Take care to prevent excavation below required grade.

E. Remove limestone formations without use of explosives.

F. Limestone excavation for footings of structures shall be carefully conducted so as to approach neat lines as closely as possible. Bed surface roughened and stepped as directed. Under no circumstances shall backfilling be placed under footings.

G. Remove existing foundation, foundation mats, footings, catch basins, manholes, underground piping, abandoned utilities, and other below grade improvements that occur within excavated areas.

3.5 EXCAVATION – BUILDING FOOTPRINT

A. Excavate soils to depths that allow for moisture conditioned soils as indicated on the drawings.

B. Building excavation shall extend a minimum of 5 feet outside the building perimeter at all areas to receive flatwork. Extend excavation **5** feet outside the building line at all building entrances.

C. Scarify the exposed subgrade to a depth of **12** inches and recompact to a minimum of 95 percent of Modified Proctor test (ASTM D 1557) at a minimum of +2 percentage points above the optimum moisture content. Stockpile excavated soils on site to be moisture conditioned and re-installed as moisture conditioned soils.

3.6 MOISTURE CONDITIONING OF SOILS BY EXCAVATION AND REPLACEMENT

A. Moisten or dry stockpiled on-site soils to achieve a moisture content a minimum of +2 percentage points above the optimum moisture content for that soil as determined by ASTM D 1557. Condition the soil using techniques that produce a uniform and consistent moisture

content.

B. Re-install the moisture conditioned soil in loose lifts, not exceeding **8** inches thick for silty/clayey sand or 12 inches for slightly silty sand, and uniformly compact to a minimum of 95 percent of Modified Standard Proctor (ASTM D 1557) at the moisture content specified above.

C. Do not allow lifts to desiccate (dry) prior to placing a subsequent lift.

D. Moisture conditioned soils shall extend outside the building line a minimum of 5 feet at all areas to receive flatwork. Extend moisture conditioned soils a minimum of 5 feet beyond the building line at all building entrances. Moisture conditioned soils that extend outside the building line shall be capped with a single lift (6 to 8 inches) of select fill to minimize drying during construction.

## 3.7 BACKFILLING – GENERAL BUILDING AREA

A. Backfilling includes filling and compaction beneath slabs and structural concrete; against and around concrete foundation walls after forms have been removed and foundation inspection completed.

B. Do not start backfilling operations until foundation drainage system and waterproofing have been reviewed, tested, and accepted.

C. Ensure areas are free from debris, snow, ice and water, and that ground surfaces are not in frozen condition.

D. Backfill areas to grades, contours, levels, and elevations indicated.

E. Backfill systematically and as early as possible to allow maximum time for natural settlement and compaction.

F. Place select fill materials in horizontal layers not exceeding 8 inches for silty/clayey sand or 12 inches for slightly silty sand loose depth and uniformly compact to a minimum of 95percent of ASTM D-1557 within + or – 2 percentage**]**points of the optimum moisture content for the soil. The first lift of select fill should be placed wet of optimum to prevent drying the moisture conditioned subgrade. Use a method so as not to disturb or damage building drainage systems and waterproofing systems.

G. Maintain optimum moisture content of backfill materials to attain specified compaction density. Moisten or dry materials as necessary.

H. Where temporary unbalanced pressures are liable to develop on walls before floor slabs are placed, erect necessary shoring to counteract imbalance.

I. Settlement or washing that occurs in backfilled areas prior to acceptance of work shall be repaired and grades re-established to required elevations and slopes.

J. Do not allow select fill to extend beyond the building line except as indicated to protect moisture conditioned soils at entrances and paving.

3.8 BACKFILLING – UTILITY TRENCHES

A. Care should be taken that utility cuts are not left open for extended periods. Do not allow water to flow along cuts to the building pad or to pond in utility cuts. Protect and/or drain utility cuts as specified herein.

B. Backfill utility cuts with properly compacted on-site soils. Use of granular materials will not be allowed.

C. Backfill for utility lines should be carefully placed so that lines will be stable. The backfill should be compacted to a minimum of 95 percent of Modified Proctor (ASTM D 1557) at a minimum of +2 percentage points above the optimum moisture content for the soil.

D. Utility cuts within five (5) feet of the building line shall be backfilled with a properly compacted on-site silty/clayey sand or slightly silty sand material to provide a positive cut-off to prevent water from migrating under the building in the utility trench backfill.

3.9 BACKFILLING – BUILDING PERIMETER

A. Backfill against the exterior face of grade beams shall be properly compacted on-site silty/clayey sand or slightly silty sand. Moisture condition, place and compact as noted above for moisture conditioning of soils by excavation and replacement

B. Select fill shall not be allowed to extend outside the limits of the building structure, except to provide a 6” layer to protect moisture conditioned soils at entrances and paving.

C. Backfill against exterior face of foundation walls shall consist of very loose slightly silty sand with an active pressure coefficient of 0.4. Wall backfill limits should extend outward at least 2 feet from the base of the wall and taper out and upward along a 1 to 1 slope (widening at the top). Backfill material shall be placed in loose lifts, less than 12” thick, and uniformly compacted to a minimum density of 95% percent of ASTM D 1557. Backfill should not be water jetted to achieve compaction and should be place at a moisture content to allow the desired relative density to be achieved.

D. The top of the very loose silty sand shall be protected by flatwork, paving or a minimum of 2 feet of clayey fill material to help prevent surface infiltration. Moisture condition, place and compact as stated above for perimeter backfill.

E. Adjust all final grades to provide positive drainage away from the building. Open ground (grassed lawns and/or landscape beds) shall be sloped at a minimum of a 5% grade for at least 10 feet away from the building perimeter or toward a drain. The contractor shall review Civil, Architectural, and Landscape drawings and report any deviations from this requirement to the Architect and Structural Engineer. Adjustments shall be made to comply with the recommendations of the geotechnical engineer as stated in the geotechnical investigation and report.

## 3.10 BACKFILLING – RETAINING WALLS

A. Backfill against heel face of retaining walls shall consist of very loose slightly silty sand with an active pressure coefficient of 0.4. Wall backfill limits should extend outward at least 2 feet from the base of the wall and taper out and upward along a 1 to 1 slope (widening at the top). Backfill material shall be placed in loose lifts, less than 12" thick, and uniformly compacted to a minimum density of 95% percent of ASTM D 1557. Backfill should not be water jetted to achieve compaction and should be place at a moisture content to allow the desired relative density to be achieved.

B. The top of the granular backfill shall be protected by flatwork, paving or a minimum of 2 feet of on-site clay material to help prevent surface infiltration. Refer to 3.6, A for compaction and moisture requirements.

## 3.11 EVALUATION OF SOILS EXPOSED TO RAIN OR DRYING

A. Maintain fill materials at specified moisture contents. Do not allow materials to dry through extended exposure. Prevent water from draining or ponding on the fill materials. Do not allow other materials to silt over the fill materials.

B. Soils exposed to drying must be re-tested by the Testing Laboratory prior to placing subsequent lifts or the concrete slab. Repair deficient earthwork as directed by the Testing Laboratory.

C. Soils exposed to significant rain must be re-tested by the Testing Laboratory. Repair damage to the subgrade and fill materials as directed by the Testing Laboratory.

## 3.12 SURPLUS MATERIALS

A. Remove excavated and excess materials from site. Legally dispose of off construction site.

## 3.13 FIELD QUALITY CONTROL

A. Monitoring and testing of compacted fill materials will be performed by testing laboratory. Refer to Division 1. Testing will be performed to least encumber performance of work.

B. Coordinate provisions for and sequence of testing with Testing Laboratory. Notify testing laboratory and allow sufficient time to perform density tests.

C. The Testing Lab shall observe and monitor the following work:
   1. Excavation operations. Determine that appropriate depths are achieved. Determine that excavation has extended as specified at building entrances. Determine that existing fills have been removed to the specified depths.

2. Preparation of exposed subgrade:
   a. Monitor proofrolling operations and direct contractor on removal of soft or pumping areas to firm ground.
   b. Monitor scarification of exposed subgrade and recompaction.
3. Monitor fill placement and compaction (full time observation for the building pad).
4. Monitor fill placement for utility trenches and perimeter backfill.
5. Monitor fill placement at entrances.
6. Monitor fill placement at foundation walls and retaining walls including construction of gravel drains with filter fabric wrap, placement of weeps, installation of continuous pipe drains, installation of free draining materials, general backfill, and clay caps (if required).

D. The Testing Lab shall perform the following testing of earthwork:
1. General Backfill Within the Building Perimeter: One set of tests for density and moisture content per 2,500 sq. ft. per lift.
2. Utility Trench Backfill: One set of tests for density and moisture content per 150 linear feet per lift.
3. Perimeter Backfill: One set of tests for density and moisture content per 75 linear feet per lift or a minimum of one set of tests per building side, per lift.
4. Building Entrances: One set of tests for density and moisture content per entrance area, per lift or a minimum of one set of tests per 50 linear feet, per lift.
5. Foundation Walls and Retaining Walls: One set of tests for density and moisture content per 75 linear feet, per lift.

E. Testing Laboratory will establish moisture density relationships of soils in accordance with ASTM D 1557, D 3017.

F. Testing Laboratory will perform in-place density test in accordance with ASTM D 1556, D 2167, D 2922, or other acceptable density tests.

G. If, during progress of work, tests indicate that compacted materials do not meet specified requirements, remove defective work, replace and retest.

H. Ensure compacted fills are tested before proceeding with placement of surface materials.

I. At the completion of work, the General Contractor shall review all test reports to verify that all deviations were corrected and re-tested until compliance was achieved. Upon request, the General Contractor shall provide written certification that all earthwork was performed in conformance with the construction documents.

## 3.14 CLEANING

A. Clean debris caused by excavation and backfill work. Keep premises and adjacent streets clean and neat.

B. Leave stockpile areas completely free of excess fill materials.

**END OF SECTION**

# SECTION 321313

# CONCRETE PAVING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes: Concrete paving for walks and includes the following.
   1. Forms.
   2. Steel reinforcement.
   3. Concrete materials.
   4. Curing materials.

B. Products Installed, but Not Furnished, under This Section:

   1. Detectable warning paving units.

C. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for general building applications of concrete.
   2. Section 321316 "Decorative Concrete Paving" for stamped concrete other than stamped detectable warnings.
   3. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.
   4. Section 321726 "Tactile Warning Surfacing" for detectable warning paving units.

### 1.2 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.

### 1.3 ACTION SUBMITTALS

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

B. Design Mixtures: For each concrete paving mixture.

1.4 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

1.5 FIELD CONDITIONS

A. 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.

B. Hot-Weather Concrete Placement: Comply with ACI 301 and as follow 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.

C. Temperature Changes: Maintain changes in concrete temperature as uniformly as possible, but in no case exceed change of 5 deg F per hour or 25 deg F in any 24-hour period.

PART 2 - PRODUCTS

2.1 CONCRETE

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.

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. Reinforcing Bars: ASTM A615/A615M, Grade 60, deformed.

B. Joint Dowel Bars: ASTM A615/A615M, Grade 60, plain-steel bars.

C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place.
   1. Use wire bar type supports or plastic-type chairs, complying with P57-66, unless otherwise indicated. Do not use wood, brick, and other unacceptable materials.
   2. For exposed-to-view concrete surfaces, where legs of support are in contact with forms, provide supports with legs which are plastic or plastic-tipped metal.

## 2.4 CONCRETE MATERIALS

A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:
   1. Portland Cement: ASTM C150/C150M, gray portland cement Type I or Type III.
   2. Fly Ash: ASTM C618, Class C or Class F.
      a. Fly ash shall comprise no more than 20% by weight of the total cementitious material in the mix.

B. Normal-Weight Aggregates: ASTM C33/C33M, Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.
   1. Fine: Clean, hard, durable, uncoated, natural sand, free of silt, loam or clay.
   2. Coarse: Hard, durable, uncoated, crushed stone; gradation in accordance with Size No. 467 for piers and concrete footings and Size No. 67 for all other concrete. Maximum aggregate size in accordance with ACI 318.
      a. Coarse aggregate for structural lightweight concrete shall conform to the applicable requirements of ASTM C330 suitably processed, washed and screened, and shall consist of durable particles without adherent coatings. Gradation in accordance with Size Designation 3/4 inch to No. 4, Table 1, ASTM C330.
      b. Grading shall be in accordance with "Standard Method for Fine Analysis of Sieve and Coarse Aggregates" (ASTM C136).

C. Water: Potable, clean and free from oil, acid and injurious amount of vegetable matter, alkalies, and other impurities and complying with ASTM C94/C94M.

D. 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.
   1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
   2. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.

E. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.

1. Manufacturer:
   a. (Scofield) SikaColor 120G, or approved equal meeting the following performance requirements.
2. Color: C14 French gray.

## 2.5 CURING MATERIALS

A. Water: Potable.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

## 3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

## 3.3 INSTALLATION OF FORMS

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 INSTALLATION OF STEEL REINFORCEMENT

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.

## 3.5 FORMING OF 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.

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.

C. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

D. 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 30 feet unless otherwise indicated.
   2. Extend joint fillers full width and depth of joint.
   3. Terminate joint filler not less than ½ 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.

E. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated on Drawings. Construct contraction joints for a depth equal to at least one-third of the concrete thickness.
   1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/4-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

## 3.6 PLACEMENT OF CONCRETE

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, 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 in accordance with 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 and dowels.

H. Screed paving surface with a straightedge and strike off.

## 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. 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.
   2. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

## 3.8 INSTALLATION OF DETECTABLE WARNING PAVING UNITS

A. Form blockouts in concrete for installation of detectable warning paving units specified in Section 321726 "Tactile Warning Surfacing".
   1. Tolerance for Opening Size: Plus ¼ inch, no minus.

## 3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained in accordance with ASTM C172/C172M will be performed in accordance with the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. Yd. 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 to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
2. Slump: ASTM C143/C143M; 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 C231/C231M, 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 C1064/C1064M; 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 C31/C31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C39/C39M; test one specimen at seven days and two specimens at 28 days.
    a. A compressive-strength test to 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 compressive-strength 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 to be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests to 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 will 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 inspection.

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.

3.10 CLEANING 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**

# SECTION 321316

# DECORATIVE CONCRETE PAVING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes: Colored concrete paving.
   1. Forms.
   2. Steel reinforcement.
   3. Concrete materials.
   4. Stain materials.
   5. Curing and sealing materials.

B. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for general building applications of concrete.
   2. Section 321313 "Concrete Paving" for cast-in-place concrete paving with other finishes, curbs and gutters, and stamped detectable warnings.
   3. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within decorative concrete paving and in joints between decorative concrete paving and other paving or adjacent construction.

### 1.2 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.

### 1.3 ACTION SUBMITTALS

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

B. Samples for Verification: For each type of exposed color, pattern, or texture indicated.

C. Design Mixtures: For each decorative concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturers of decorative concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M 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").

C. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 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.

1.5 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.

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.

B. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration indicated. Provide solid backing and form supports to ensure stability of textured form liners.

C. 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. Reinforcing Bars: ASTM A615/A615M, Grade 60; deformed.

B. Joint Dowel Bars: ASTM A615/A615M, Grade 60 plain-steel bars. Cut bars true to length with ends square and free of burrs.

C. 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.

2.4 CONCRETE MATERIALS

A. Cementitious Materials:
   1. Portland Cement: ASTM C150/C150M, white portland cement Type I Type III.
   2. Fly Ash: ASTM C618, Class C or F.

B. Normal-Weight Aggregates: ASTM C33/C33M, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.
   1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Air-Entraining Admixture: ASTM C260/C260M.

D. 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.
   1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
   2. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.

E. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. (Scofield) Sika Corporation, or approved equal meeting the performance requirements.

F. Water: Potable and complying with ASTM C94/C94M.

## 2.5 CURING AND SEALING MATERIALS

A. Curing Paper: Nonstaining, waterproof paper, consisting of two layers of kraft paper cemented together and reinforced with fiber, and complying with ASTM C171.

## 2.6 CONCRETE MIXTURES

A. Obtain each color, size, type, and variety of concrete mixture from single manufacturer with resources to provide concrete of consistent quality in appearance and physical properties.

B. 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.

C. Cementitious Materials: Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing and retarding admixture in concrete as required for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

G. Concrete Mixtures: Normal-weight concrete.
   1. Compressive Strength (28 Days): 3500 psi.

## 2.7 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to

ASTM C94/C94M. 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 C94/C94M. 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. 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.

B. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

### 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 INSTALLATION OF STEEL REINFORCEMENT

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.

E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap to adjacent mats.

## 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.

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. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
   1. Locate expansion joints at intervals of 30 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-third of the concrete thickness.

1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/4-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

## 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.

## 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.

## 3.8 INTEGRALLY COLORED CONCRETE FINISH

A. Integrally Colored Concrete Finish: After final floating, apply the following finish:
   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.

## 3.9 SANBLAST FINISH

A. Expose aggregate and produce uniform matte, abraded texture in paving surface as follows.
   1. Do not sandblast paving surface until concrete has cured a minimum of 14 days or has attained 75 percent of specified 28-day compressive strength, whichever is later.
   2. Protect adjacent surfaces, plant material, and site elements not indicated to receive sandblast finish from overspray and abrasive media using tarps, plywood shielding, or other means acceptable to Architect.
   3. Perform sandblasting using dry or wet abrasive-blasting equipment with media, nozzle size, and air pressure recommended by equipment manufacturer to achieve depth of finish indicated without fracturing or over-exposing aggregate.
   4. Hold nozzle perpendicular to surface at consistent standoff distance and traverse rate to produce uniform texture and exposure depth across entire surface; avoid overlapping passes that produce banding or blotching.
   5. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate, unless deeper exposure is indicated.
   6. Because sandblasting removes surface cement paste and integral coloring pigment is distributed uniformly throughout the mix, verify with concrete supplier that pigment dosage and mix design are suitable for the specified blast depth; increased pigment dosage may be required to prevent color washout or exposed-aggregate areas reading lighter or grayer than adjacent unblasted, integrally colored surfaces.
   7. Rinse blasted surface with clean water immediately after blasting to remove abrasive residue and dust; do not allow residue to dry on surface.
   8. Apply sealer or curing compound only after surface has dried and been approved, using product compatible with integrally colored, exposed-aggregate concrete and that does not alter color or gloss level unevenly across blasted and unblasted areas.

## 3.10 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. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

D. Curing Compound: Apply immediately after final finishing. 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.
   1. Cure integrally colored concrete with a pigmented curing compound.
   2. Cure concrete finished with pigmented mineral dry-shake hardener with a pigmented curing compound.

E. Curing and Sealing 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. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating, and repair damage during curing period.

F. Curing Paper: Cure with unwrinkled curing paper in pieces large enough to cover the entire width and edges of slab. Do not lap sheets. Fold curing paper down over paving edges and secure with continuous banks of earth to prevent displacement or billowing due to wind. Immediately repair holes or tears in paper.

## 3.11 SEALER APPLICATION

A. Clear Acrylic Sealer: Apply uniformly in two coats in continuous operations according to manufacturer's written instructions. Allow first coat to dry before applying second coat, at 90 degrees to the direction of the first coat, using same application methods and rates.
   1. Begin sealing dry surface no sooner than 14 days after concrete placement.
   2. Allow stained concrete surfaces to dry before applying sealer.
   3. Thoroughly mix slip-resistance-enhancing additive into sealer before applying sealer according to manufacturer's written instructions. Stir sealer occasionally during application to maintain even distribution of additive.

## 3.12 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C172/C172M shall be performed according to the following requirements:
   1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. 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 C143/C143M; 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 C231/C231M, 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 C1064/C1064M; 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 C31/C31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C39/C39M; 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 compressive-strength 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. Decorative 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.

## 3.13 REPAIR

A. Remove and replace decorative concrete paving that is broken or damaged or does not comply

with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.

## 3.14 PROTECTION

A. Protect decorative 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.

B. Maintain decorative 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**

# SECTION 321373

# CONCRETE PAVING JOINT SEALANTS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes:
   1. Cold-applied joint sealants.
   2. Joint-sealant backer materials.
   3. Primers.

B. Related Requirements:
   1. Section 079200 "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.

### 1.2 ACTION SUBMITTALS

A. Product Data:
   1. Concrete pavement joint sealants.
   2. Joint-sealant backer materials.

### 1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Installers: Entity that employs installers and supervisors who are trained and approved by manufacturer.

### 1.4 FIELD 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.
   2. When joint substrates are wet.
   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 SOURCE LIMITATIONS

A. Obtain joint sealants from single manufacturer.

## 2.2 JOINT SEALANTS, GENERAL

A. Compatibility: Provide joint sealants, backer 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.

## 2.3 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Self-Leveling, Polyurethane Joint Sealant: ASTM C920, Type S or M, Grade P, Class25.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal meeting the performance requirements.
      a. W.R. Meadows, Inc. (Pourthane SL)
      b. Sika Corporation (Sikaflex 1c SL)
      c. Pecora Corporation (Urexpan NR-201)
      d. Tremco (Vulkem 45SSL)
         1) Color: Color to match adjacent concrete.

## 2.4 JOINT-SEALANT BACKER MATERIALS

A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

B. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

## 2.5 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

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

## 3.2 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.
   1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

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. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

## 3.3 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backers to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backer materials.
   2. Do not stretch, twist, puncture, or tear joint-sealant backer materials.
   3. Remove absorbent joint-sealant backer materials that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backer material installation, using proven techniques that comply with the following:
   1. Place joint sealants so they fully contact joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants in accordance with the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
   1. Remove excess joint sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

## 3.4 CLEANING AND PROTECTION

A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

B. 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 in repaired areas are indistinguishable from the original work.

**END OF SECTION**

**SECTION 321400**

**UNIT PAVING**

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Concrete pavers.

B. Related Requirements:
   1. Section 321313 "Concrete Paving" for concrete base under unit pavers and for cast-in-place concrete curbs and gutters serving as edge restraints for unit pavers.
   2. Section 321400 "Tactile Warning Surfacing" for incorporating warning unit pavers for tactile warning surfacing.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. For the following:
      a. Pavers.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: A qualified unit paving installer. Installer's field supervisor must have Concrete Paver Installer Certification from the Interlocking Concrete Pavement Institute (ICPI) with one of the following designations:
   1. Commercial Paver Technician Designation.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

1.5 FIELD 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.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 CONCRETE PAVERS

A. Concrete Pavers, Solid Interlocking Paving Units: Complying with ASTM C936/C936M and resistant to freezing and thawing when tested according to ASTM C67, made from normal-weight aggregates.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Hanover Architectural Products, or approved equal meeting the following performance requirements.
         1) Thickness: 4”.
         2) Face Size and Shape:2 7/8”-by-17 5/8” rectangle.
         3) Color: GCB91002 Ground Tudor.
         4) Finish: Tudor finish.

2.3 AGGREGATE SETTING-BED MATERIALS

A. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.

B. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 sieve and no more than 10 percent passing No. 200 sieve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

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

## 3.2 PREPARATION

A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.

B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

## 3.3 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
   1. For concrete pavers, a block splitter may be used.

D. Joint Pattern: Running Bond.

E. Tolerances:
   1. Do not exceed 1/32-inch unit-to-unit offset from flush (lippage) or 1/8 inch in 10 feet from level, or indicated slope, for finished surface of paving.
   2. Do not exceed 1/16-inch unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches and 1/4 inch in 10 feet from level, or indicated slope, for finished surface of paving.

## 3.4 AGGREGATE SETTING-BED APPLICATIONS

A. Place leveling course and screed to a thickness of 1 to 1-1/2 inches, taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.

B. Set pavers with a minimum joint width of 1/16 inch and a maximum of 1/8 inch, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch with pieces cut to fit from full-size unit pavers.

C. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
   1. Before ending each day's work, compact installed concrete pavers except for 36-inch width of uncompacted pavers adjacent to temporary edges (laying faces).

2. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within 36 inches of laying face.
3. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.

D. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.

E. Do not allow traffic on installed pavers until sand has been vibrated into joints.

F. Repeat joint-filling process 30 days later.

## 3.5 REPAIRING, POINTING, AND CLEANING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Pointing: During tooling of joints, enlarge voids or holes and completely fill with grout. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.

C. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.
1. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.

D. Do not allow protective coating to enter floor drains. Trap, collect, and remove coating material.

**END OF SECTION**

# SECTION 321726

# TACTILE WARNING SURFACING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This Section includes:
   1. Detectable warning unit pavers.

B. Related Requirements:
   1. Section 321313 "Concrete Paving" for concrete walkways serving as substrates for tactile warning surfacing.
   2. Section 321400 "Unit Paving" for unit paving installations incorporating detectable warning unit pavers specified in this Section.

### 1.2 ACTION SUBMITTALS

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

### 1.3 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.

## 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 UNIT PAVERS

A. Detectable Warning Concrete Unit Pavers: Solid paving units, made from normal-weight concrete with a compressive strength of not less than 5000 psi, water absorption of not more than 5 percent according to ASTM C140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C67, with accessible detectable warning truncated domes on exposed surface of units.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Hanover Architectural Products, Inc., or approved equal meeting the following performance requirements.
   2. Shapes and Sizes:
      a. Thickness: 2 inch at field of tile (not including dome thickness).
      b. Face Size: Nominal 24 inch rectangle.
   3. Dome Spacing and Configuration: 2.35-inch spacing, in manufacturer's standard pattern.
   4. Color: Charcoal.
   5. Setting Bed: Comply with requirements in Section 321400 "Unit Paving".
   6. Aggregate Setting Bed:
      a. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D448 for Size No. 8.
      b. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.

B. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 sieve and no more than 10 percent passing No. 200 sieve.

# 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. 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 UNIT PAVERS

A. Unit Paver Installation:
   1. Setting-Bed and Unit Paver Installation: Comply with installation requirements in Section 321400 "Unit Paving".
   2. Mix unit pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
   3. Cut unit pavers with motor-driven masonry saw equipment to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible.
   4. Tolerances: Do not exceed 1/4 inch in 10 feet from level, or indicated slope, for finished surface of paving.

B. Aggregate Setting-Bed Applications:
   1. Place aggregate base, compact by tamping with plate vibrator, and screed to depth indicated.
   2. Place leveling course and screed to a thickness of 1 to 1-1/2 inches, taking care that moisture content remains constant and density is loose and uniform until unit pavers are set and compacted.
   3. Treat leveling course with herbicide to inhibit growth of grass and weeds.
   4. Set unit pavers with a minimum joint width of 1/16 inch and a maximum of 1/8 inch, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines.
   5. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf compaction force at 80 to 90 Hz.
   6. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.

## 3.4 CLEANING

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.

## 3.5 PROTECTION

A. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

**END OF SECTION**

**SECTION 323300**

**SITE FURNISHINGS**

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Seating.
   2. Tables.
   3. Bicycle racks.
   4. Bollards.
   5. Flagpoles.

B. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for installing pipe sleeves cast, installing anchor bolts cast in concrete footings.
   2. Section 312000 "Earth Moving" for excavation for installing concrete footings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of specified product

PART 2 - PRODUCTS

2.1 SEATING

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Landscape Forms, Inc., Trapecio Bench, or approved equal meeting the following performance requirements.
      a. Support: 6-3/4" wide x 3/8" thick steel plate, welded together, Hot Dip Galvanized.
      b. Seat and back panels: Concrete: Reinforced cast stone.
      c. Anchoring: Surface mount below grade.
      d. Bench length: 212-1/4 inches.
      e. Back Length: 177 inches.
      f. Seat Length: 177 inches.
      g. Seat height is 16-1/4 inches.
      h. Color: Earth.
   2. Landscape Forms, Inc., Harvest Bench, or approved equal meeting the following performance requirements.
      a. Support frame: aluminum extrusions, bolted to 10ga carbon steel plate.

b. Seat: high-density polyethylene (HDPE)
c. Arms: none.
d. Anchoring: Surface mount
e. Bench length: 94 inches.
f. Bench height: 18.75 inches.
g. Color (Frame): Silver Metallic Powder Coat Finish
h. Color (Seat): Charcoal Gray Powder Coat

3. Landscape Forms, Inc., Glide Bench, or approved equal meeting the following performance requirements.
   a. Support frame: Formed 14-gauge A1008 CR type B
   b. Seat: high-density polyethylene (HDPE)
   c. Arms: none.
   d. Anchoring: Surface.
   e. Bench Length: 75 inches.
   f. Bench Heigth:31.25 inches.
   g. Color: Silver Metallic Powder Coat Finish
4. Landscape Forms, Inc., Socrates Bench, or approved equal meeting the following performance requirements.
   a. Seat material: Cast stone concrete.
   b. Anchoring: Freestanding
   c. Arms: none.
   d. Bench Length: 142 inches.
   e. Bench Heigth:18 inches.
   f. Color: Grey
5. Canaan Site Furnishings, Metal Transit Bench CAL-717, or approved equal meeting the following performance requirements.
   a. Support frame: Galvanized steel flat bar.
   b. Seat: 8mm Sheet metal.
   c. Arms: Both ends
   d. Back: Standard back
   e. Anchoring: Surface mount.
   f. Bench Length: 72 inches.
   g. Bench Height: 18 ¾ inches.
   h. Color: Signal Grey
6. Canaan Site Furnishings, Backless Transit Bench CAL-717, or approved equal meeting the following performance requirements.
   a. Support frame: Galvanized steel flat bar.
   b. Seat: 8mm Sheet metal.
   c. Arms: Both ends
   d. Back: Backless
   e. Anchoring: Surface mount.
   f. Bench Length: 72 inches.
   g. Bench Height: 18 ¾ inches.
   h. Color: Signal Grey

2.2 TABLE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Landscape Forms, Inc., Harvest Table, or approved equal meeting the following performance requirements.
      a. Support frame: aluminum extrusions, bolted to 10ga carbon steel plate.
      b. Tabletop: high-density polyethylene (HDPE)
      c. Anchoring: Surface mount
      d. Table length: 94.75 inches.
      e. Table width: 47.5 inches.
      f. Table height: 30.25 inches.
      g. Color: Silver Metallic Powder Coat Finish

2.3 BICYCLE RACK

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Forms+Surfaces, Capital Bike Rack, or approved equal meeting the following performance requirements.
      a. Body: Cast aluminum.
      b. Anchoring: Surface mount with embedding anchors.
      c. Rack height: 34 inches.
      d. Rack length: 5 inches.
      e. Rack width: 4 inches.
      f. Color: Silver Texture Powder Coat Finish

2.4 BOLLARD

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Landscape Forms, Inc., Profile Bollard, or approved equal meeting the following performance requirements.
      a. Vertical post: aluminum extrusion, welded to top cap and base plate.
      b. Top cap and base plate: 1/2” thick aluminum plate.
      c. Bottom cover: aluminum casting.
      d. Anchoring: Surface mount
      e. Bollard height: 36 inches.
      f. Bollard length: 6.5 inches
      g. Bollard width: 6.5 inches.
      h. Color: Metallic Powder Coat Finish

2.5 FLAGPOLE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Concord American Flagpole, Titan Series IWW30D71-BZT, or approved equal meeting the following performance requirements.
      a. Pole height: 30 feet

b. Anchoring: Ground set.
c. Color: Bronze Tone Powder Coat Finish.

## 2.6 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces.

E. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

F. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

## 2.7 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

## 2.8 STEEL AND GALVANIZED-STEEL FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

## 2.9 PVC FINISH

A. Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with

coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.

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

3.2 INSTALLATION OF SITE FURNISHINGS

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

**END OF SECTION**

# SECTION 328400

# PLANTING IRRIGATION

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes:
   1. Pipes, tubes, and fittings.
   2. Drip irrigation.
   3. Miscellaneous materials.
   4. Valves.
   5. Sprinklers.
   6. Quick couplers.
   7. Controllers.

B. Provide complete landscape irrigation system as shown on drawings as described herein.

C. Related Requirements:
   1. Section 220500 "Common Work Results for Plumbing" for water metering requirements.
   2. Section 230923.14 "Flow Instruments" for water metering equipment.
   3. Section 329200 "Turf and Grasses" for turf (lawn).
   4. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants.

### 1.2 DEFINITIONS

A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

C. ET Controllers: Evapotranspiration Controllers. Irrigation controllers, which use some method of weather-based adjustment of irrigation. These adjusting methods include use of historical monthly averages of ET, broadcasting of ET measurements, or use of on-site sensors to track ET.

D. Mainline Piping: Piping from the point of connection to the water distribution system, downstream through to and including the control/operating valves. This piping remains under water-distribution-system pressure at all times. It includes hydrant lines and lines supplying quick coupling valves (QCVs)

E. Lateral Piping: Piping from operating valves to sprinkler heads.

F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

## 1.3 QUALITY ASSURANCE

A. Installer:
   1. An irrigator licensed in the State of Florida with a minimum five (5) years continuous experience installing systems of this size and complexity must supervise system installation.
   2. If requested, submit a list of references including Owner, Landscape Architect (if applicable), date of installation and approximate installation cost.

B. Testing: Perform required testing under observations of Architect. Give forty-eight hours' notice that such tests are to be conducted.

C. Assembly Procedures: Do not alter design hydraulics by installing additional tees or elbows unless approved by Architect.

D. Install system per all State of Florida laws and rules and all local codes and ordinances. These items are made apart of these specifications whether shown or not. State of Florida laws and rules and all local codes and ordinances take precedence over the plans and specifications.

E. Furnish certificates showing which materials have been manufactured within a five Hundred (500) mile radius of the site per LEED requirement MRc5.1 – Regional Materials.

## 1.4 REFERENCE STANDARDS

A. American Standard for Testing and Materials (ASTM) - Latest edition.
   1. D2241 Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
   2. D2464 Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Thread, Schedule 80
   3. D2466 Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
   4. D2467 Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Socket Type, Schedule 80
   5. D2564 Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
   6. D2287 Flexible Poly Vinyl Chloride (PVC) Plastic Pipe
   7. F656 Poly Vinyl Chloride (PVC) Solvent Weld Primer
   8. D2855 Making Solvent - Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.

## 1.5 SUBMITTALS

A. Procedure: Comply with Division I Specifications requirements.

B. Product Data: Submit copies of equipment manufacturer's specifications and literature for all specified materials.

C. Project Record Documents.

PART 2 - PRODUCTS

2.1 POLYVINYL CHLORIDE PIPE

A. Chloride Pipe (PVC): Manufactured in accordance with standards noted.
   1. PVC Mainline and Lateral Piping: Class 200, SDR-21. Pipe shall be permanently marked with ASTM standard number and the NSF (National Sanitation Foundation) seal. Provide pipe free of blisters, internal striation, cracks, or other defects.
   **2.** PVC Pipe Fittings: Schedule 40.
      a. Solvents: Weld-On #795 by IPS Corporation.
      b. Primer: Weld-On #P-68 by IPS Corporation.

B. Pipe Connection Materials:
   1. Solvent Weld Fittings:
   2. Threaded Fittings: PVC to PVC, or PVC to copper, use Teflon tape.
   3. Flexible PVC: Use only solvents made for flexible pipe.
      a. Solvents: Weld-On #795 by IPS Corporation.
      b. Primer: Weld-On #P-68 by IPS Corporation.
      c. Do not use spiral barbed fittings with flexible PVC. Refer to drawing details.

2.2 COPPER PIPE MATERIALS

A. Pipe: Type “M”, hard, straight lengths of standard size and dimension.

B. Fittings: Cast brass of wrought copper, sweat-solder type.

C. Pipe Connection Materials: Threaded fitting, copper to copper, copper to brass, and copper to PVC: Teflon tape.

2.3 DRIP IRRIGATION

A. Control zone values to have pressure regulator and filter per manufacturer’s recommendations.
   1. Filter to be 200 mesh and installed in a “Y” body.
   2. Pressure Regulator and electric valve shall be “low flow” models made specifically for drip irrigation.

B. Inline Emitter Tubing: Tubing to have factory installed, pressure compensating, inline emitters installed every 12” on center. Flow rate to be .90 gallons per hour.

C. Compression fittings
   1. Provide leak free compression connections.
   2. Use flush cap to close off line.
   3. ABS materials with Buna-N rubber seals.
   4. Air Relief Valves: Made of quality rust-proof plastic material with a maximum pressure rating of 140 psi.

5. Flush Valves: Made of quality rust-proof plastic material with a maximum pressure rating of 57 psi.
6. Soil Staples: 12-gauge galvanized steel pre-bent rod staple. Stake to be corrosion-resistance with notches.

## 2.4 MISCELLANEOUS MATERIALS

A. Wire: Type UF with minimum 4/64 inches insulation, Underwriters Laboratory (UL) approved for direct underground burial in National Electrical Code Class II Circuit (30 volts AC or less). Size according to controller manufacturer's recommendations and consideration of length of run, but no smaller than #14.

B. Nipples:
   **1.** Spray Pop-Up heads: Flexible PVC manufactured from virgin PVC material and tested at 200 psi; static pressure for two hours with a quick burst rating of 400 psi min. manufactured by Agrifim (NDS).
   **2.** Rotary heads: Schedule 80 PVC, Type 1, Grade 1, plus Lasco swing joint assemblies with 'O-Ring' fittings.

C. Pea Gravel: Washed native aggregate graded 3/4 to 1-1/2 inches.

D. Wire Connectors: Waterproof splice kit connectors. Type DBY by 3M or King One Step sealant filled connector.

E. Quick Coupler Valves and Keys:
   1. Valves: One inch (1") bronze bodied valves with a rubber seat and purple vinyl cover.
   2. Keys: Bronze construction with one inch (1") MIP x ¾" FIP threads

## 2.5 IRRIGATION EQUIPMENT

A. Refer to drawing notes and legend.

# PART 3 - EXECUTION

## 3.1 INSPECTION

A. Examine areas to be sprinkled and conditions under which irrigation sprinkler system is to be installed.

B. Verify that interfacing work specified elsewhere is complete.

C. Notify Architect in writing of conditions detrimental to proper irrigation coverage and timely completion of Work.

D. Do not proceed until conditions are satisfactory.

## 3.2 INSTALLATION

A. General
   1. Complete installation in strict accordance with manufacturer's recommendation, State of Florida laws are rule and all local codes and ordinances which shall be considered a part of these specifications.
   2. Staking: Stake location of each sprinkler before proceeding. Do not exceed manufacturer's maximum spacing limits for the stated head pressure.
   3. Piping Layout: Piping layout is diagrammatic. Route piping around trees and shrubs to avoid damage to plantings. Do not dig within balls of newly planted trees and shrubs. Also, if applicable, do not trench within the dripline of existing trees. These trenches must be dug by hand.
   4. Discrepancies
      a. Point out any discrepancy between the drawings and the field conditions that may affect uniform coverage. Do not proceed until any design change made necessary by such discrepancy is approved.
      b. Should such changes create extra cost, approval for extra compensation shall be obtained in writing before commencing work.
      c. Should such changes create a savings in cost, a written reduction in the contract price shall be approved in writing before commencing work.
      d. If Contractor fails to comply with Item a. above, and proceeds with the installation, then the Contractor assumes responsibility for cost of subsequent system modifications to assure that uniform water coverage is achieved.

B. Excavations: Excavations are unclassified and include earth, rock, or combinations, in wet or dry state. Backfill trenches with material removed except if rock is encountered, haul this material off site and backfill to ensure a minimum of 3 inches of rock-free soil surrounding pipe.

C. Water Meter and Backflow Prevention: Refer to drawings.

## 3.3 PIPE INSTALLATION

A. General: Width of trenches to be approximately twice as large as the pipe diameter.
   1. Maintain a minimum horizontal distance of 3’-0” between any valves that are installed side by side.
   2. Maintain a minimum 1’-6” distance between any fittings installed in the main line and lateral lines (except for reducer bushings). Crosses are not allowed.

B. Mainline Piping: Install in 4-inch wide trenches with minimum of 18 inches of cover over pipe, but no more than 24 inches of cover.

C. Lateral Piping: Install in 4-inch-wide trenches with minimum 12 inches of cover over pipe, but no more than 18 inches of cover.

D. Trenching: Provide firm, uniform bearing for entire length of pipe to prevent uneven settlement. Wedging or blocking of pipe is not permitted. Remove foreign matter from inside of pipe before welding. Keep inside of piping clean during and after layout.

E. Backfill: Water jet and compact to prevent after settling. Hand rake trenches and adjoining areas to leave grade in condition equal to before installation.

## 3.4 PVC PIPE AND FITTINGS ASSEMBLY

A. Solvent: Use solvent and procedures recommended by manufacturer to make solvent-welded joints. Thoroughly clean pipe and fittings with purple primer before applying solvent.

B. PVC to Metal Connections: Use Teflon tape

C. Threaded PVC Connections: Use threaded PVC adapters into which pipe may be welded. Use Teflon tape on threads.

## 3.5 COPPER PIPE AND FITTINGS ASSEMBLY

A. Clean pipe and fittings thoroughly and buff connections with sandpaper to remove residue from pipe.

B. Flux pipe and fitting and solder connection using "No-Lead" solder.

## 3.6 REMOTE CONTROL AND GATE VALVES

A. Provide valves in accordance with materials list and size according to drawings.

B. Install valves in a level position in accordance with manufacturer's specifications and per paragraph 3.3 (4.2).

C. Center a plastic valve box over valve, flush with finish grade. Provide valve box extensions as required.

D. Install 0.5 cubic feet washed pea gravel in bottom of valve box.

## 3.7 SPRINKLERS

A. General: Provide in accordance with materials list, with nozzling in accordance with Drawings. Change nozzle degree and trajectory if wind conditions affect coverage. Receive approval from the Architect prior to any change. Install heads adjacent to walks and curbs two (4) inches clear of paving. Avoid excess water on walks, walls, fences, etc.

B. Lawn Pop-up Heads: Attach sprinklers to lateral piping with flexible PVC and schedule 80 fittings. Use solvent made especially for flexible PVC. Firmly tamp soil around base plate and

leave head plumb. Set top of sprinkler ¼" above finish grade. Provide strainer in each head. Refer to drawing details.

C. Rotary Heads: Attach to lateral piping with pre-manufactured Lasco swing joint assemblies and schedule 80 PVC. Refer to drawing details.

## 3.8 DRIP IRRIGATION

A. Install drip control zone valve in accordance with manufacturer's recommendations.

B. Install headers and sub headers. Headers to be PVC Class 200. Maximum distance between headers to be 80'-0".

C. Install flush valves and air relief valves as required by the manufacturer or as shown on the plans. Install flush valves and air relief valves per manufacturer's recommendations. In general, flush valves to be installed at the lowest point of the zone and air relief valves on the highest point of the zone.

D. Thoroughly flush all headers before drip tubing is installed.

E. Tubing to be staked at 4'-0" on center (minimum) along length of tubing. Use "u" pins specifically made for use with drip tubing.

## 3.9 QUICK COUPLING VALVE (QCV)

A. Provide in accordance with materials list and as detailed on Drawings. Stake with galvanized pipe securely attached to QCV with two stainless steel worm gear clamps. Install with individual shut off valve. QVC and shut off valve to be installed in valve box with purple lid.

## 3.10 WIRING

A. No conduit shall be required for U.F. wire, unless otherwise noted on Drawings. Tuck wire under piping.

B. Make wire connections with waterproof non-hardening two-piece connectors according to manufacturer's recommendations.

C. Provide a separate wire from controller to each electric valve. Provide a common neutral wire from controller to valves served by a particular controller.

D. Provide 24-inch long wire coils at valves.

E. Bundle wires together with waterproof electrical tape at ten-foot intervals.

## 3.11 TEMPERATURE SENSOR

A. Exterior Controller: Securely mount sensor on bottom of controller, or if pedestal controllers are specified, mount sensor to the inside of the pedestal using stainless steel nuts, bolts and lock nuts. Secure bulb probe flat against outside of controller with nylon wire strip. Remove bracket usually supplied with unit and reuse bolts.

B. Interior Controller:
   1. Locate sensor probe in a location exposed to outside air temperature. Receive Architect's approval of location prior to installation. Seal opening with silicone sealant.
   2. Provide electrical conduit for connection from sensor box to controller. Securely fasten conduit permanently to wall in manner appropriate for wall material.

C. Use separate conduit or remote control valve wire conduit for sensor. Do not install in same conduit with 115V power supply.

D. Locate as directed by Architect or Landscape Architect.

## 3.12 RAIN SENSOR

A. Pedestal Mount Controller: Unless noted otherwise, securely attach rain gauge to top of 2" galvanized pipe 10' above grade and 2' below grade set in concrete. Locate sensor probe in a location exposed to outside rain conditions. Refer to drawing details.

B. Wall mount Controller: Unless noted otherwise, securely attach rain gauge to top of building parapet or wall. Locate sensor probe in a location exposed to outside conditions. Refer to drawing details.

C. Use separate conduit or remote-control valve wire conduit for sensor. Do not install in same conduit with 115V power supply.

D. Locate as directed by Architect or Landscape Architect.

## 3.13 TESTING

A. Notify Landscape Architect to review work 48 hours prior to testing pipe and fittings for leaks.

B. Test mains for a period of four (4) hours under static pressure. If leaks (or pressure drops) occur, correct defect and repeat test.

## 3.14 FINAL ADJUSTMENT

A. Make final adjustments of sprinkler system prior to Architect's final inspection.

B. Flush system by removing nozzles from heads.

C. Adjust sprinklers for proper operation and proper alignment for direction of throw.

D. Adjust each section for operating pressure and balance to other sections by use of flow adjustment on top of each valve. Correct operating pressure at last head of each section – 45 to 50 psi for rotary heads and 25 to 30 psi for spray heads.

E. Adjust nozzling for proper coverage. Prevailing wind conditions or slopes may indicate that arc of angle or trajectory of spray should be other than as shown on drawings. Change nozzles to provide correct coverage.

F. Provide all items as required by State of Florida laws and rules and all local codes and ordinances.

3.15 CLEAN UP

A. Keep premises clean and neat.

**END OF SECTION**

# SECTION 329200

# TURF AND GRASSES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes:
   1. Turfgrass sod.

B. Related Requirements:
   1. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.

### 1.2 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" and drawing designations for planting soils.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

### 1.3 ACTION SUBMITTALS

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

### 1.4 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful

turf establishment.

1. Professional Membership: Installer must be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.
2. Experience: Five years' experience in turf installation in addition to requirements in Section 014000 "Quality Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

## 1.5 DELIVERY, STORAGE, AND HANDLING

A. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

## 1.6 FIELD CONDITIONS

A. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

# PART 2 - PRODUCTS

## 2.1 TURFGRASS SOD

A. Turfgrass Sod: Certified, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
   1. Turfgrass Species, Warm-Season Grass: St. Augustine grass (Stenotaphrum secundatum) and shall consist of stolons, leaf blades and roots with a healthy, virile system of dense, thickly matted roots throughout the soil of the sod for a thickness not less than one inch. Sod shall be alive, healthy and vigorous and shall be free of insects, disease, stones and undesirable foreign materials and grasses. Sod shall have been produced on growing beds of clay or clay-loam topsoil. The sod shall not be harvested or planted when its

moisture condition is so excessively wet or dry that its survival will be affected. If sod is stacked, it shall be kept moist and shall be stacked roots-to-roots and grass-to-grass.

B. Cut Sod Blocks: Sod shall be cut in sixteen- or eighteen-inch-wide strips by two feet wide to be laid parallel with the contours.

C. Big Roll Sod: Sod shall be cut in strips forty-two inch wide to be laid parallel with the contours.

## 2.2 FERTILIZER

A. All fertilizer shall be delivered in bags or containers clearly labeled, showing the analysis.

B. All fertilizer shall be in acceptable condition for distribution and shall be applied uniformly over the planted area two weeks after sodding.

C. All fertilizer shall have an analysis of 3-1-2 or as designated on the plans. The fertilizer rate shall be 45 pounds of nitrogen per acre.

## 2.3 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   3. Uniformly moisten excessively dry soil that is not workable or which is dusty.

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

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

## 3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
   1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
   2. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

## 3.3 PREPARATION OF TURF AREA

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."

B. Placing Planting Soil: Place manufactured planting soil over exposed subgrade.
   1. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

## 3.4 INSTALLATION OF TURFGRASS SOD

A. Lay sod within 24 hours of harvesting unless a suitable preservation method is accepted by Landscape Architect prior to delivery time. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
   1. Lay sod across the slope, parallel to finished grade contours.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

## 3.5 MAINTENANCE OF TURF

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf.

Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
   1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
   2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
   1. Mow St Augustine grass to a height of 1 1/2 to 2 inches.

D. Turf Postfertilization: Apply slow-release fertilizer after initial mowing and when grass is dry.
   1. Use fertilizer that provides actual nitrogen of at least 45 pounds per acre to turf area.

## 3.6 SATISFACTORY TURF

A. Turf installations will meet the following criteria as determined by Architect:
   1. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

## 3.7 CLEANUP

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Remove nondegradable erosion-control measures after grass establishment period.

3.8 PROTECTION

A. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

3.9 MAINTENANCE SERVICE FOR TURF

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until owner occupancy has occured, but for not less than the following periods:

B. Sodded Turf: 30 days from date of planting completion

**END OF SECTION**

# SECTION 329300

# PLANTS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes:
   1. Plant materials.
   2. Fertilizers.
   3. Weed-control barriers.
   4. Mulches.
   5. Herbicides and pesticides.
   6. Tree stabilization materials.
   7. Landscape edgings.

B. Related Requirements:
   1. Section 015639 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
   2. Section 328400 "Planting Irrigation" for complete irrigation systems.
   3. Section 329200 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.

### 1.2 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
   1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

### 1.3 ACTION SUBMITTALS

A. Product Data:
   1. Plant materials.
   2. Fertilizers.
   3. Weed-control barriers.
   4. Mulches.
   5. Landscape edgings.

B. Product Data Submittals: For each product.
   1. Plant Materials: Include quantities, sizes, quality, and verified sources for plant materials.

C. Samples for Verification: Actual sample of finished products for each of the following:
   1. Organic Mulch: 1-quart volume of each organic mulch required; typical of the lot of material to be furnished, in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Provide an accurate representation of color, texture, and organic makeup.
   2. Weed-Control Barrier: 12 by 12 inches.
   3. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.

## 1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

## 1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
   1. Professional Membership: Member in good standing of either the National Association of Landscape Professionals or AmericanHort.
   2. Experience: Five years' experience in landscape installation in addition to requirements in Section 014000 "Quality Requirements."
   3. Installer's Field Supervision: Maintain an experienced full-time supervisor on Project site when work is in progress.
   4. Personnel Certification: Installer's field supervisor certified in one of the following categories from the National Association of Landscape Professionals:
      a. Landscape Industry Certified Technician - Exterior.
      b. Landscape Industry Certified Horticultural Technician.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
   1. Selection of plants purchased under allowances is made by Architect, who tags plants at their place of growth before they are prepared for transplanting.
   2. All plants shall conform to the standards for Florida Grade No1., or better as provided in the latest edition of Grades and Standards for Nursery Plants, Division of Plant Industry, Florida Department of Agriculture and Consumer Services.

C. Measurements: Measure in accordance with ANSI Z60.1. Don’t prune to obtain required sizes.
   1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
   2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar,

size, and quality. Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Architect of sources of planting materials 7 days in advance of delivery to site.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, or walkways and pavements; or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

D. Handle planting stock by root ball.

E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
   1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   2. Do not remove container-grown stock from containers before time of planting.
   3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

## 1.7 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.
   1. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be

obtained. Apply products during favorable weather conditions in accordance with manufacturer's written instructions and warranty requirements

## PART 2 - PRODUCTS

### 2.1 PLANT MATERIALS

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
   1. Trees with damaged, crooked, or multiple leaders; with tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); with crossing trunks; with cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.
   2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare in accordance with ANSI Z60.1.

### 2.2 FERTILIZERS

A. Granular Fertilizer:
   1. Phosphorus-containing fertilizer may only be used if a UF/IFAS-approved soil or tissue test documents a deficiency, applied at the rate/timing the test and local rule dictate. Fertilizers must comply with Florida’s statewide fertilizer rule restricting phosphorus.
   2. Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
      a. 3 percent nitrogen, 4 percent phosphorous, and 3 percent potash, by weight.

B. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, 33 percent hydrogel, and maximum of 5.5 percent inert material.

### 2.3 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and

shrubs, consisting of one of the following:
1. Type: Pine straw mulch.

## 2.4 HERBICIDES AND PESTICIDES

A. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

## 2.5 TREE-STABILIZATION MATERIALS

A. Proprietary Root Ball Stabilization Devices: Proprietary at or below grade biodegradable stabilization system to secure each new planting by root ball and that do not encircle the trunk, sized in accordance with manufacturer's written instructions unless otherwise indicated:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. ArborStakes, LLC. (www.ArborStakes.com), or approved equal.

## 2.6 LANDSCAPE EDGINGS

A. Steel Edging: Standard commercial-steel edging, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. J. D. Russell Company (The), or approved equal meeting the performance requirements.
   2. Edging Size: 1/8 inch thick by 4 inches deep.
   3. Stakes: Tapered steel, a minimum of 15 inches long.
   4. Accessories: Standard tapered ends, corners, and splicers.
   5. Finish: Manufacturer's standard paint.
      a. Paint Color: Black.

## 2.7 MISCELLANEOUS PRODUCTS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix in accordance with manufacturer's written instructions.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
3. Suspend planting operations during periods of excessive soil moisture until moisture content reaches acceptable levels to attain required results.
4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove soil and contamination as directed by Architect and replace with new planting soil.

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

## 3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

## 3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil in accordance with Section 329113 "Soil Preparation."

B. Placing Planting Soil: Blend planting soil in place.

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate in accordance with manufacturer's written instructions.

## 3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.
   1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
   2. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
   3. Do not excavate deeper than depth of root ball, measured from the root flare to the bottom of root ball.
   4. If area under the plant was initially dug too deep, add soil to raise it to correct level and thoroughly tamp the added soil to prevent settling.
   5. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
   6. Maintain supervision of excavations during working hours.
   7. Keep excavations covered or otherwise protected after working hours.
   8. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.

B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

## 3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball in accordance with ANSI Z60.1. If root flare is not visible, remove soil in a level manner from root ball to where the top-most root emerges from the trunk. After soil removal to expose root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
   1. Backfill: Planting soil. For trees, use excavated soil for lower 2/3 of planting pit. Planting soil for the back filling of the upper 1/3 of the tree planting pit.
   2. After placing some backfill around root ball to stabilize plant, carefully cut and remove

burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Distribute granular fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole.
   a. Quantity: Three for each caliper inch of plant.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
1. Backfill: Planting soil. For trees, use excavated soil for lower 2/3 of planting pit. Planting soil for the back filling of the upper 1/3 of the tree planting pit.
2. Carefully remove root ball from container without damaging root ball or plant.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Distribute granular fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of root ball.

## 3.6 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Do not apply pruning paint to wounds.

## 3.7 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on Drawings in even rows with triangular spacing.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to depth not less than two nodes.

E. Work soil around roots to eliminate air pockets and leave slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

## 3.8 INSTALLATION OF MULCHES

A. Mulch backfilled surfaces of planting areas and other areas indicated.
   1. Trees and Treelike Shrubs in Turf Areas: Apply organic mulch ring of 3-inch average thickness, with 36-inch radius around trunks or stems. Do not create a mulch cone or place mulch within 6 inches of trunks or stems.
   2. Organic Mulch in Planting Areas: Apply 3-inch average thickness of organic mulch over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

## 3.9 INSTALLATION OF LANDSCAPE EDGINGS

A. Steel Edging: Install steel edging where indicated in accordance with manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

## 3.10 APPLICATION OF HERBICIDES AND PESTICIDES

A. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written instructions.

## 3.11 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

## 3.12 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform tree pit percolation tests.
2. Tree pit construction will be considered defective if it does not pass percolation tests and inspections.
3. Do not proceed with planting in tree pits until satisfactory percolation is demonstrated.

B. Prepare test and inspection reports.

## 3.13 REPAIR AND REPLACEMENT

A. Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
1. Submit details of proposed pruning and repairs.
2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in unhealthy condition before end of corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
1. Provide new trees of same size as those being replaced for each tree of 4 inches or smaller in caliper size.
2. Species of Replacement Trees: Same species being replaced.

## 3.14 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After installation and before Owner Occupancy, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

E. At time of Owner Occupancy, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

**END OF SECTION**