



# ANNE ARUNDEL COUNTY HERITAGE COMPLEX – RTU REPLACEMENT

## FINAL SPECIFICATIONS

September 22, 2023

Contract No. C537800  
AACo Project No. C537896

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

230513	COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
230593	TESTING, ADJUSTING, AND BALANCING FOR HVAC
230713	DUCT INSULATION
233113	METAL DUCTS
233300	AIR DUCT ACCESSORIES
237313	ROOF MOUNTED AIR HANDLING UNITS

**DIVISION 26 - ELECTRICAL**

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260523	GROUNDING AND BONDING
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## **SECTION 230513**

### **COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

#### **PART 1 - GENERAL**

##### 1.1 RELATED DOCUMENTS

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

##### 1.2 SUMMARY

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

##### 1.3 COORDINATION

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

#### **PART 2 - PRODUCTS**

##### 2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

##### 2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

## 2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
  - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
  - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
  - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
  - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

## 2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

## 2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

### **PART 3 - EXECUTION (Not Applicable)**

END OF SECTION 230513

## SECTION 230593

### TESTING, ADJUSTING, AND BALANCING FOR HVAC

#### PART 1 - GENERAL

##### 1.1 RELATED DOCUMENTS

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

##### 1.2 SUMMARY

- A. Section Includes:
  - 1. Balancing Air Systems:
    - a. Constant-volume air systems.
  - 2. Testing, Adjusting, and Balancing Equipment:
    - a. Motors.
    - b. Condensing units.

##### 1.3 DEFINITIONS

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

##### 1.4 ACTION SUBMITTALS

- A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation indicating that work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report for Prerequisite EA 2: Documentation indicating that work complies with ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. Instrument calibration reports, to include the following:
  1. Instrument type and make.
  2. Serial number.
  3. Application.
  4. Dates of use.
  5. Dates of calibration.

#### 1.6 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC.
  1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
  2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

#### 1.7 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. 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.

### **PART 2 - PRODUCTS (Not Applicable)**

### **PART 3 - EXECUTION**

#### 3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, 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 applicable for intended purpose and 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 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 verify that bearings are greased, belts are aligned and tight, filters are clean, 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 have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, 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.
- 3.2 PREPARATION
- A. Prepare a TAB plan that includes the following:
1. Equipment and systems to be tested.
  2. Strategies and step-by-step procedures for balancing the systems.
  3. Instrumentation to be used.
  4. Sample forms with specific identification for all equipment.

- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
  - 1. Airside:
    - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
    - b. Duct systems are complete with terminals installed.
    - c. Volume, smoke, and fire dampers are open and functional.
    - d. Clean filters are installed.
    - e. Fans are operating, free of vibration, and rotating in correct direction.
    - f. Variable-frequency controllers' startup is complete and safeties are verified.
    - g. Automatic temperature-control systems are operational.
    - h. Ceilings are installed.
    - i. Windows and doors are installed.
    - j. Suitable access to balancing devices and equipment is provided.

### 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
  - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
  - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
  - 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."
- C. 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.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

### 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

### 3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

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

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

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

### 3.7 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. 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:
  - a. Indicated versus final performance.
  - b. Notable characteristics of systems.
  - c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.

15. Test conditions for fans and pump performance forms including the following:
  - a. Settings for outdoor-, return-, and exhaust-air dampers.
  - b. Conditions of filters.
  - c. Cooling coil, wet- and dry-bulb conditions.
  - d. Face and bypass damper settings at coils.
  - e. Fan drive settings including settings and percentage of maximum pitch diameter.
  - f. Settings for supply-air, static-pressure controller.
  - g. Other system operating conditions that affect performance.
  
- D. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
  1. Unit Data:
    - a. Unit identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and unit size.
    - e. Manufacturer's serial number.
    - f. Unit arrangement and class.
    - g. Discharge arrangement.
    - h. Sheave make, size in inches, and bore.
    - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    - j. Number, make, and size of belts.
    - k. Number, type, and size of filters.
  
  2. Motor Data:
    - a. Motor make, and frame type and size.
    - b. Horsepower and rpm.
    - c. Volts, phase, and hertz.
    - d. Full-load amperage and service factor.
    - e. Sheave make, size in inches, and bore.
    - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
  
  3. Test Data (Indicated and Actual Values):
    - a. Total airflow rate in cfm.
    - b. Total system static pressure in inches wg.
    - c. Fan rpm.
    - d. Discharge static pressure in inches wg.
    - e. Filter static-pressure differential in inches wg.
    - f. Preheat-coil static-pressure differential in inches wg.
    - g. Cooling-coil static-pressure differential in inches wg.
    - h. Heating-coil static-pressure differential in inches wg.
    - i. Outdoor airflow in cfm.

- j. Return airflow in cfm.
  - k. Outdoor-air damper position.
  - l. Return-air damper position.
  - m. Vortex damper position.
- E. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
- 1. Report Data:
    - a. System and air-handling-unit number.
    - b. Location and zone.
    - c. Traverse air temperature in deg F.
    - d. Duct static pressure in inches wg.
    - e. Duct size in inches.
    - f. Duct area in sq. ft.
    - g. Indicated airflow rate in cfm.
    - h. Indicated velocity in fpm.
    - i. Actual airflow rate in cfm.
    - j. Actual average velocity in fpm.
    - k. Barometric pressure in psig.
- F. Air-Terminal-Device Reports:
- 1. Unit Data:
    - a. System and air-handling unit identification.
    - b. Location and zone.
    - c. Apparatus used for test.
    - d. Area served.
    - e. Make.
    - f. Number from system diagram.
    - g. Type and model number.
    - h. Size.
    - i. Effective area in sq. ft.
  - 2. Test Data (Indicated and Actual Values):
    - a. Airflow rate in cfm.
    - b. Air velocity in fpm.
    - c. Preliminary airflow rate as needed in cfm.
    - d. Preliminary velocity as needed in fpm.
    - e. Final airflow rate in cfm.
    - f. Final velocity in fpm.
    - g. Space temperature in deg F.

ANNE ARUNDEL CO. DEPARTMENT OF PUBLIC WORKS  
HERITAGE COMPLEX - RTU REPLACEMENT  
County Contract No. C537896  
FINAL Submission

RMF Engineering, Inc.  
RMF No. 121004.A0  
September 22, 2023

END OF SECTION 230593

## **SECTION 230713**

### **DUCT INSULATION**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes insulating the following duct services:
  - 1. Indoor, concealed supply and outdoor air.
  - 2. Indoor, exposed supply and outdoor air.
  - 3. Indoor, concealed return located in unconditioned space.
  - 4. Indoor, exposed return located in unconditioned space.
  - 5. Indoor, concealed oven and warewash exhaust.
  - 6. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
  - 7. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
- B. Related Sections:
  - 1. Section 230719 "HVAC Piping Insulation."
  - 2. Section 233113 "Metal Ducts" for duct liners.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
  - 3. Detail application of field-applied jackets.
  - 4. Detail application at linkages of control devices.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

#### 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

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

#### 1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

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

**PART 2 - PRODUCTS**

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    - a. CertainTeed Corporation.
    - b. Johns Manville; a Berkshire Hathaway company.
    - c. Knauf Insulation.
    - d. Manson Insulation Inc.
    - e. Owens Corning.
- F. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

## 2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

## 2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
  - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
  - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
  - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
  - 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
  - 4. Color: White.
- D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
  - 3. Solids Content: 60 percent by volume and 66 percent by weight.
  - 4. Color: White.

## 2.4 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Fire- and water-resistant, flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
  - 4. Color: Aluminum.

## 2.5 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
  - 1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

## 2.6 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

## 2.7 TAPES

- A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
  - 1. Width: 3 inches.
  - 2. Thickness: 6.5 mils.
  - 3. Adhesion: 90 ounces force/inch in width.
  - 4. Elongation: 2 percent.
  - 5. Tensile Strength: 40 lbf/inch in width.
  - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

## 2.8 SECUREMENTS

- A. Bands:
  - 1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
  - 2. Aluminum: ASTM B 209 , Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
  - 3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Insulation Pins and Hangers:
  - 1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
  - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
  - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
  - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
  - a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
  - b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
  - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
  - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
  - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
  - c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
  - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

- 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.080-inch nickel-copper alloy.

## 2.9 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch , PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch , aluminum according to ASTM B 209 , Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch , stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

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

### 3.2 PREPARATION

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

### 3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  - 1. Install insulation continuously through hangers and around anchor attachments.
  - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
  - 1. Draw jacket tight and smooth.
  - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
  - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    - a. For below ambient services, apply vapor-barrier mastic over staples.
  - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
  - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

### 3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
  - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
  - 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
  - 1. Comply with requirements in Section 078413 "Penetration Firestopping."

### 3.5 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
  - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
  - b. On duct sides with dimensions larger than 18 inches , place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
  - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
  - d. Do not overcompress insulation during installation.
  - e. Impale insulation over pins and attach speed washers.
  - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
  - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
  - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

### 3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

### 3.7 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed oven and warewash exhaust.
6. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
7. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

### 3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round supply-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Concealed, round and return-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

- C. Concealed, round and outdoor-air duct insulation shall be the following:
  - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- D. Concealed, round and exhaust-air duct insulation shall be the following:
  - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- E. Concealed, rectangular, supply-air duct insulation shall be the following:
  - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- F. Concealed, rectangular, return-air duct insulation shall be the following:
  - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- G. Concealed, rectangular, outdoor-air duct insulation shall be the following:
  - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- H. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
  - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

END OF SECTION 230713

## SECTION 233113

### METAL DUCTS

#### PART 1 - GENERAL

##### 1.1 RELATED DOCUMENTS

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

##### 1.2 SUMMARY

- A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Double-wall round ducts and fittings.
4. Sheet metal materials.
5. Duct liner.
6. Sealant and gaskets.
7. Hangers and supports.

- B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

##### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

- B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
6. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

- a. Lighting fixtures.
  - b. Air outlets and inlets.
  - c. Speakers.
  - d. Sprinklers.
  - e. Access panels.
  - f. Perimeter moldings.
- B. Welding certificates.
- C. Field quality-control reports.

#### 1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
  - 1. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

### **PART 2 - PRODUCTS**

#### 2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-

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

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

## 2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - 1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
  - 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

## 2.3 DOUBLE-WALL ROUND DUCTS AND FITTINGS

- A. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
- B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
  - 1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
    - a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
  - 2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
    - a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
    - b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
  - 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Inner Duct: Minimum 0.028-inch solid sheet steel.
- D. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
  - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
  - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
  - 3. Coat insulation with antimicrobial coating.
  - 4. Cover insulation with polyester film complying with UL 181, Class 1.

- E. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
  - 1. Maximum Thermal Conductivity:  $0.25 \text{ Btu} \times \text{in./h} \times \text{sq. ft.} \times \text{deg F}$  at  $75 \text{ deg F}$  mean temperature.

## 2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G60.
  - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
  - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## 2.5 DUCT LINER

- A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
  - 1. Maximum Thermal Conductivity:
    - a. Type I, Flexible:  $0.27 \text{ Btu} \times \text{in./h} \times \text{sq. ft.} \times \text{deg F}$  at  $75 \text{ deg F}$  mean temperature.
    - b. Type II, Rigid:  $0.23 \text{ Btu} \times \text{in./h} \times \text{sq. ft.} \times \text{deg F}$  at  $75 \text{ deg F}$  mean temperature.
  - 2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
  - 3. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

- a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
  2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel aluminum stainless steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
  2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
  3. Butt transverse joints without gaps, and coat joint with adhesive.
  4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
  5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
  6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
  7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
  8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
    - a. Fan discharges.
    - b. Intervals of lined duct preceding unlined duct.
    - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
  9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

- a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.
10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

## 2.6 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
  1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
  2. Tape Width: 4 inches.
  3. Sealant: Modified styrene acrylic.
  4. Water resistant.
  5. Mold and mildew resistant.
  6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  7. Service: Indoor and outdoor.
  8. Service Temperature: Minus 40 to plus 200 deg F.
  9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
  10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Water-Based Joint and Seam Sealant:
  1. Application Method: Brush on.
  2. Solids Content: Minimum 65 percent.
  3. Shore A Hardness: Minimum 20.
  4. Water resistant.
  5. Mold and mildew resistant.
  6. VOC: Maximum 75 g/L (less water).
  7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
  2. Type: S.
  3. Grade: NS.
  4. Class: 25.
  5. Use: O.
  6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
  2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
  3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

## 2.7 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

**PART 3 - EXECUTION**

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

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

### 3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

### 3.3 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
  - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - 2. Outdoor, Supply-Air Ducts: Seal Class A.
  - 3. Outdoor, Exhaust Ducts: Seal Class C.
  - 4. Outdoor, Return-Air Ducts: Seal Class C.
  - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
  - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
  - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
  - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
  - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
  - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
  - 11. Conditioned Space, Exhaust Ducts: Seal Class B.

12. Conditioned Space, Return-Air Ducts: Seal Class C.

### 3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  1. Where practical, install concrete inserts before placing concrete.
  2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
  4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
  5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

### 3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

### 3.6 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099000 "Painting."

### 3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
  - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
  - 2. Test the following systems:
    - a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
  - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  - 4. Test for leaks before applying external insulation.
  - 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
  - 6. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
  - 1. Visually inspect duct system to ensure that no visible contaminants are present.
  - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
    - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.8 START UP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

- a. Pressure Class: Positive 1-inch wg.
- b. Minimum SMACNA Seal Class: C.
- c. SMACNA Leakage Class for Rectangular: 12.
- d. SMACNA Leakage Class for Round and Flat Oval: 12.

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

- a. Pressure Class: Positive 3-inch wg.
- b. Minimum SMACNA Seal Class: B.
- c. SMACNA Leakage Class for Rectangular: 6.
- d. SMACNA Leakage Class for Round and Flat Oval: 6.

B. Return Ducts:

1. Ducts Connected to Fan Coil Units, Heat Pumps, and Terminal Units:

- a. Pressure Class: Positive or negative 1-inch wg.
- b. Minimum SMACNA Seal Class: C.
- c. SMACNA Leakage Class for Rectangular: .
- d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

- a. Pressure Class: Positive or negative 3-inch wg.
- b. Minimum SMACNA Seal Class: B.
- c. SMACNA Leakage Class for Rectangular: 12.
- d. SMACNA Leakage Class for Round and Flat Oval: 12.

C. Exhaust Ducts:

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

- a. Pressure Class: Negative 3-inch wg.
- b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
- c. SMACNA Leakage Class for Rectangular: 24.

- d. SMACNA Leakage Class for Round: 12.
2. Ducts Connected to Air-Handling Units:
  - a. Pressure Class: Positive or negative 3-inch wg.
  - b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
  - c. SMACNA Leakage Class for Rectangular: 12.
  - d. SMACNA Leakage Class for Round: 12.
- D. Intermediate Reinforcement:
  1. Galvanized-Steel Ducts: Galvanized steel.
  2. PVC-Coated Ducts:
  3. Aluminum Ducts: Aluminum.
- E. Liner:
  1. Supply Air Ducts: Fibrous glass, Type I, 1 inch thick.
  2. Transfer Ducts: Fibrous glass, Type I, 1 inch thick.
- F. Double-Wall Duct Interstitial Insulation:
  1. Supply Air Ducts: 1 inch thick.
  2. Return Air Ducts: 1 inch thick.
  3. Exhaust Air Ducts: 1 inch thick.
- G. Elbow Configuration:
  1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
    - a. Velocity 1000 fpm or Lower:
      - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      - 2) Mitered Type RE 4 without vanes.
    - b. Velocity 1000 to 1500 fpm:
      - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
    - c. Velocity 1500 fpm or Higher:

- 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
  - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
  - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
    - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
  3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
    - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      - 4) Radius-to Diameter Ratio: 1.5.
    - b. Round Elbows, and Smaller in Diameter: Stamped or pleated.
    - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- H. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
    - a. Rectangular Main to Rectangular Branch: 45-degree entry.
    - b. Rectangular Main to Round Branch: Spin in.
  2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

- a. Velocity 1000 fpm or Lower: 90-degree tap.
- b. Velocity 1000 to 1500 fpm: Conical tap.
- c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

## SECTION 233300

### AIR DUCT ACCESSORIES

#### PART 1 - GENERAL

##### 1.1 RELATED DOCUMENTS

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

##### 1.2 SUMMARY

- A. Section Includes:

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

- B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

##### 1.3 ACTION SUBMITTALS

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

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

- B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
  - a. Special fittings.
  - b. Manual volume damper installations.
  - c. Control-damper installations.
  - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
  - e. Duct security bars.
  - f. Wiring Diagrams: For power, signal, and control wiring.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

#### 1.5 MAINTENANCE MATERIAL SUBMITTALS

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

### **PART 2 - PRODUCTS**

#### 2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

#### 2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  1. Galvanized Coating Designation: G90.

2. Exposed-Surface Finish: Mill phosphatized.

B. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

### 2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Subject to compliance with requirements, provide a product by one of the following:

1. Greenheck.
2. Nailor Industries, Inc.
3. Ruskin Company.
4. Flex-Tek Group
5. Pottorff
6. Cesco Products.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1250 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel, with welded corners or mechanically attached.

F. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch width, 0.025-inch- thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Galvanized steel.
2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Aluminum.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.

2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
  - a. Sleeve Thickness: 20 gage minimum.
  - b. Sleeve Length: 6 inches minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Galvanized steel.
8. Screen Type: Insect.
9. 90-degree stops.

#### 2.4 BAROMETRIC RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. American Warming and Ventilating; a Mestek Architectural Group company.
  2. Cesco Products; a division of MESTEK, Inc.
  3. Greenheck Fan Corporation.
  4. Lloyd Industries, Inc.
  5. Nailor Industries Inc.
  6. NCA Manufacturing, Inc.
  7. Pottorff.
  8. Ruskin Company.
  9. Safe Air - Dowco Products.
  10. Vent Products Co., Inc. Suitable for horizontal or vertical mounting.
- B. Maximum Air Velocity: 1250 fpm.
- C. Maximum System Pressure: 2-inch wg.
- D. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel, with welded corners or mechanically attached.
- E. Blades:
1. Multiple, 0.025-inch- thick, roll-formed aluminum.
  2. Maximum Width: 6 inches.
  3. Action: Parallel.
  4. Balance: Gravity.
  5. Eccentrically pivoted.
- F. Blade Seals: Vinyl.

- G. Blade Axles: Galvanized steel Nonferrous metal Plated steel Stainless steel Nonmetallic.
- H. Tie Bars and Brackets:
  - 1. Material: Aluminum.
  - 2. Rattle free with 90-degree stop.
- I. Return Spring: Adjustable tension.
- J. Bearings: Stainless steel.
- K. Accessories:
  - 1. Flange on intake.
  - 2. Adjustment device to permit setting for varying differential static pressures.

## 2.5 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
  - 1. Subject to compliance with requirements, provide a product by one of the following:
    - a. Aire Technologies
    - b. Flexmaster U.S.A., Inc.
    - c. Flex-Tek Group
    - d. McGill Airflow LLC
    - e. Nailor Industries, Inc.
    - f. Pottorff
    - g. Ruskin Company
    - h. Trox USA Inc.
  - 2. Standard leakage rating, with linkage outside airstream.
  - 3. Suitable for horizontal or vertical applications.
  - 4. Frames:
    - a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel.
    - b. Mitered and welded corners.
    - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
  - 5. Blades:
    - a. Multiple or single blade.
    - b. Parallel- or opposed-blade design.
    - c. Stiffen damper blades for stability.
    - d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:
  - a. Oil-impregnated bronze.
  - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Galvanized steel.

## 2.6 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Aire Technologies.
  2. American Warming and Ventilating; a Mestek Architectural Group company.
  3. Arrow United Industries.
  4. Cesco Products; a division of MESTEK, Inc.
  5. Greenheck Fan Corporation.
  6. Nailor Industries Inc.
  7. NCA Manufacturing, Inc.
  8. Pottorff.
  9. Prefco.
  10. Ruskin Company.
  11. Safe Air - Dowco Products.
  12. Vent Products Co., Inc.
  13. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Type: Static; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 3000-fpm (is-m/s) velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Curtain type with blades inside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
  1. Minimum Thickness: 0.138 inch thick, as indicated, and of length to suit application.
  2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.

- H. Blades: Roll-formed, interlocking, 0.024-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

## 2.7 FLANGE CONNECTORS

- A. Description: Add-on, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- B. Material: Galvanized steel.
- C. Gage and Shape: Match connecting ductwork.

## 2.8 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
  - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vaness and Vane Runners," and 4-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall.
- E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

## 2.9 DUCT-MOUNTED ACCESS DOORS

- A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
  - 1. Door:
    - a. Double wall, rectangular.

- b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
  - c. Vision panel.
  - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
  - e. Fabricate doors airtight and suitable for duct pressure class.
- 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
  - 3. Number of Hinges and Locks:
    - a. Access Doors Less Than 12 Inches square: No hinges and two sash locks.
    - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
    - c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches.
    - d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

#### 2.10 DUCT ACCESS PANEL ASSEMBLIES

- A. Labeled according to UL 1978 by an NRTL.
- B. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
- C. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- E. Minimum Pressure Rating: 10-inch wg, positive or negative.

#### 2.11 FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.
- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4 inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd..
  - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
  - 3. Service Temperature: Minus 40 to plus 200 deg F.

## 2.12 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flexmaster U.S.A., Inc.
  2. JP Lamborn Co.
  3. McGill AirFlow LLC.
  4. Thermaflex; a Flex-Tek Group company.
  5. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene aluminized vapor-barrier film.
1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
  2. Maximum Air Velocity: 4000 fpm.
  3. Temperature Range: Minus 20 to plus 175 deg F.
  4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.
- C. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
  2. Non-Clamp Connectors: Adhesive Liquid adhesive plus tape Adhesive plus sheet metal screws.

## 2.13 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
  - 1. Install steel volume dampers in steel ducts.
  - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire dampers according to UL listing.
- H. Install duct security bars. Construct duct security bars from 0.164-inch steel sleeve, continuously welded at all joints and 1/2-inch diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  - 1. On both sides of duct coils.
  - 2. Upstream and downstream from duct filters.
  - 3. At outdoor-air intakes and mixed-air plenums.
  - 4. At drain pans and seals.
  - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
  - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
  - 7. At each change in direction and at maximum 50-foot spacing.
  - 8. Upstream and downstream from turning vanes.

9. Upstream or downstream from duct silencers.
  10. Control devices requiring inspection.
  11. Elsewhere as indicated.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
1. One-Hand or Inspection Access: 8 by 5 inches.
  2. Two-Hand Access: 12 by 6 inches.
  3. Head and Hand Access: 18 by 10 inches.
  4. Head and Shoulders Access: 21 by 14 inches.
  5. Body Access: 25 by 14 inches.
  6. Body plus Ladder Access: 25 by 17 inches.
- L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
- N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- P. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- Q. Connect flexible ducts to metal ducts with draw bands.
- R. Install duct test holes where required for testing and balancing purposes.
- S. 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.

### 3.2 FIELD QUALITY CONTROL

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

4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

## SECTION 237313

### ROOF MOUNTED AIR HANDLING UNITS

#### PART 1 - GENERAL

##### 1.1 REFERENCE STANDARDS

- A. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality; 2016.
- B. ASTM B177/B177M - Standard Guide for Engineering Chromium Electroplating; 2011.
- C. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc; Current Edition, Including All Revisions.

#### PART 2 - PRODUCTS

##### 2.1 MANUFACTURERS

###### A. GENERAL

- 1. Manufacturer of packaged unitary rooftop products shall have had a minimum of five years successful experience in the manufacture and service support of the rooftop packages. Manufacturers with less than five years experience in the production of rooftop units shall not be acceptable.

###### APPROVED MANUFACTURERS

- 1. Trane - IntelliPak RE50
  - 2. Daikin
  - 3. JCI/York
  - 4. Substitutions: [Prior approval required] as indicated under the general and/or supplemental conditions of these specifications.
- B. Base bid shall be Trane packaged rooftop air conditioning units with approved alternate being York, or Daikin. Alternates must still comply with the performance and features as specified herein and as indicated on the design documents. Job will be awarded on basis of specified product. Substitutions must be selected and approved within 14 calendar days after award of contract.

##### 2.2 GENERAL UNIT DESCRIPTION

- A. Unit(s) furnished and installed shall be packaged rooftops as specified on the contract documents and within these specifications. Cooling capacity ratings shall be based upon AHRI Standard 340/360. Unit(s) shall consist of insulated weathertight casing with compressors, air cooled

condenser coil, condenser fans, evaporator coil, filters, supply and/or relief fan motors and drives, and unit controls.

- B. Package units shall be constructed for installation on a roof curb providing full perimeter support under air handler section and pedestal support under condenser section.
- C. Unit(s) shall be factory run tested to include the operation of all fans, compressors, heat exchangers, and control sequences.
- D. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

### 2.3 UNIT CASING

- A. Cabinet: Exterior panels shall be zinc coated galvanized steel painted with a baked enamel finish durable enough to withstand a minimum of 672 hours consecutive salt spray application in accordance with standard ASTM B117. Screws shall be coated.
- B. Refrigeration components and compressor shall be accessible through removable louvered panels as standard.
- C. Unit air handling section shall have a pitched roof and laminated double-wall construction with polyurethane foam core injected between sheet metal panels. Insulation value shall be R9. All interior surfaces shall be suitable for cleaning per ASHRAE 62. All access doors and panels shall have closed cell gaskets. All door, roof and base panels shall have a thermal break.
- D. Unit base shall be watertight with heavy gauge formed load-bearing members and curb overhang. Unit lifting lugs shall accept chains or cables for rigging. Lifting lugs shall also serve as unit tie down points.
- E. Access Doors: Access doors shall be hinged with a single, exterior mounted, height and tension adjustable handle to provide positive latching at three points. Access doors shall provide a door stop mechanism to latch the door in the open position to prevent unsafe door closure by wind. Serviceable compartments in the air handler such as filters, evaporator coil, supply fan and variable frequency drives shall have doors of laminated, double-wall construction. This construction shall use a polyurethane foam core between the exterior sheet metal pane and the interior line, with an insulating value of R9. Three single wall doors shall be provided for access to the control panel.

### 2.4 ELECTRICAL POWER CONNECTIONS

- A. Provide Phase Voltage Monitor. Shall protect 3-phase equipment from phase loss, phase reversal and phase imbalance. Any fault condition shall produce a Failure Indicator LED and send the unit into an auto stop condition.

- B. Provide Unit Interrupt Rating (Short Circuit Current Rating-SCCR). A 5,000 Amp rating Amp rating shall be applied to the unit enclosure using a non-fused circuit breaker for disconnect switch purposes. Fan motors, compressors, and electric heat circuits shall be provided with series rated circuit breakers that will provide the unit rated level of protection. The unit shall be marked with approved cULus markings and will adhere to cULus regulations
- C. Provide Non-Fused Disconnect. External handle mounted on the control box door shall be provided to disconnect unit power with the control box door closed for safety.
- D. Provide unit mounted 115 volt convenience outlet. Shall be wired and powered from a factory mounted transformer. Unit-mounted, non-fused disconnect with external handle shall be furnished with factory powered outlet.
- E. Unit shall be single point power.

## 2.5 PRE EVAPORATOR COOLER AIR FILTERS

- A. Provide Air Filters. Filters shall mount integral within unit casing and be accessible via hinged access panels.
- B. Provide filter monitoring. A factory-installed, differential pressure transducer shall be piped to both sides of the pre evaporator filter and final filter to indicate status. Transducer shall maintain +/- 5 percent accuracy within operating temperature limits of -20°F to 120°F. Transducer shall be mounted in a unit control box and report status through unit control display.
- C. Provide MERV 14 cartridge filters. Cartridge filters shall be 12-inch thick, MERV 14 microglass paper media attached to 24 ga galvanized steel frame, and shall slide into a galvanized steel rack. Option shall also include 2-inch thick, MERV 8 panel pre-filters of disposable synthetic media to provide extended cartridge lif

## 2.6 FANS - SUPPLY

- A. Supply fan shall be a minim of 2 single width, single inlet 9-blade plenum fans. Fan blades shall be aluminum airfoil. Plenum fans shall be direct-driven. Entire assembly shall be completely isolated from unit and fan board by 2" deflection spring isolation.
- B. Beltless fan shall not require routine maintenance such as fan bearing lubrication, belt tensioning and replacement, sheave alignment, and setscrew torque checks.
- C. Supply fan motors shall be open drip-proof. All supply fans shall be dynamically balanced in factory. Each motor shall have its own Variable Frequency Drive (VFD). VFDs shall be factory provided and unit mounted. Control of VFDs shall be compatible with the relief fan section and ECM arrangement.
- D. Supply fan shall be test run in unit and shall reach rated rpm. All 60 Hz supply fan motors shall meet the Energy Independence Security Act of 2007 (EISA).

## 2.7 ELECTRIC HEATING SECTION

- A. All electric heat models shall be completely assembled and wired. Electric heat control shall be fully integrated with the unit controls. Heavy duty nickel chromium elements internally wired with a maximum density of 35.5 watts per square inch shall be provided. Heater circuits shall be 45 amps or less, each individually fused. Automatic reset high limit control shall operate through heater.
- B. Electric heat models shall include modulating SCR control.

## 2.8 EVAPORATOR COIL SECTION

- A. Provide heavy duty aluminum fins mechanically bonded to copper tubes. Evaporator coil shall be inter-circuited to maintain active coil face area at part load conditions. Coil shall also utilize internally enhanced tubing for maximum efficiency.
- B. Provide electronic expansion valve. Shall be electronically controlled by the unit controller. This fully integrates expansion valve control with unit operation to ensure optimal equipment reliability and efficiency. Expansion valves shall be 2500 step valves for precise refrigerant control and shall be driven closed during off cycles to minimize refrigerant migration and protect compressors. Valve position shall be displayed at the user interface to assist field diagnostics.
- C. Provide stainless steel pressure transducer. Shall provide accurate measurement of high and low side refrigeration system pressure over the entire operating range. System pressures and saturation temperatures shall be displayed at the user interface to improve field diagnostics. The transducer is accessible as it shall be located close to the compressor manifold set. Durable weather proof automotive grade electrical connectors shall be used to ensure reliability.
- D. Provide sloped stainless steel drain pan to assure positive drainage of condensate from the unit casing.

## 2.9 AIR-COOLED CONDENSER SECTION

- A. Condenser coils shall have all Aluminum Microchannel coils. All coils shall be leak tested at the factory to ensure pressure integrity. The condenser coil is pressure tested to 650 psig. Subcooling circuit(s) shall be provided as standard.
- B. Provide subcooling circuit(s) integral with condenser coils to maximize efficiency and prevent premature flashing of liquid refrigerant, to a gaseous state, ahead of the expansion valve.
- C. Provide vertical discharge, direct drive, condenser fans with aluminum blades and zinc plated steel hubs. Condenser fan motors shall be three-phase motors with permanently lubricated ball bearings, built-in current and thermal overload protection and weather-tight slingers over motor bearings.

- D. Provide factory-installed louvered steel hail/vandal guards around perimeter of condensing section to protect the condenser coils, refrigerant piping and control components from damage resulting from hail, flying debris, and vandalism. Louvered panels shall be fabricated from heavy gauge, pre-painted galvanized steel with a baked, polyurethane enamel finish, and be rigid enough to provide permanent protection for shipping and pre-/post- installation.

#### 2.10 REFRIGERATION SYSTEM

- A. Compressor shall be industrial grade, energy efficient direct drive 3600 RPM speed scroll type. The motor shall be of a suction gas cooled hermetic design. Compressor shall have a centrifugal oil pump with dirt separator, oil sight glass, and oil charging valve. Crankcase heaters will be standard on each compressor to minimize amounts of liquid in the oil sump when unit is off.
- B. Provide with thermostatic motor winding temperature control to protect against excessive motor temperatures resulting from over-/under-voltage or loss of charge. Provide high and low pressure cutouts, and reset relay.
- C. Provide factory-installed compressor lockout thermostat to prevent compressor operation at low ambient conditions.
- D. Provide coil frost protection compressor unloading based on refrigerant circuit suction temperature to prevent coil frosting with minimum energy usage.
- E. Variable speed compressors shall be capable of speed modulation from 25 Hz to a maximum of 100 Hz. The minimum unit capacity shall be 15% of full load or less. The compressor motor shall be a permanent magnet type. Each compressor shall have a crankcase heater installed, properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles. Compressors shall be equipped with a bearing oil injection system that optimizes bearing and scroll set lubrication, sealing, and controls the oil circulation rate. Optimal bearing lubrication shall be provided by an oil pump.
- F. Each variable speed compressor shall be matched with a specially designed variable frequency drive which modulates the speed of the compressor motor and provides several compressor protection functions. Control of the variable speed compressor and inverter shall be integrated with the Symbio 800 unit controller to ensure optimal equipment reliability and efficiency.
- G. F. Provide high efficiency units that shall meet ASHRAE 189.1-2011 and Consortium for Energy Efficiency (CEE) Advanced Tier Commercial Unitary AC and HP Specification for utility rebate requirement
- H. Provide Compressor Isolation Valves. Factory installed valves both upstream and downstream of each compressor set shall enable isolation of compressors from the rest of the refrigeration system if service is required.

## 2.11 RELIEF SECTION

- A. Provide Relief Fan – Direct Drive & Variable Speed with Statitrac Control. The eDrive™ relief fan shall be a minimum of two single-width, single-inlet, 5-blade direct-drive plenum fans with backward inclined, high efficiency welded aluminum impeller that is dynamically balanced as an assembly. Fan shall be beltless and maintenance free throughout its operating life. Fan shall be balanced to G6.3 per AMCA 204. Entire fan assembly shall be completely isolated from unit and fan board by 2" deflection spring isolation. Motor shall contain power electronics for speed control and be managed by the equipment controller.
- B. The modulating relief discharge dampers and ECM shall be modulated in response to building pressure. A differential pressure control system, (Statitrac™), shall use a differential pressure transducer to compare indoor building pressure to outdoor ambient atmospheric pressure. The relief fan shall be turned on when required to lower building static pressure setpoint.
- C. The (Statitrac™) control system shall then modulate the discharge dampers and ECM to control the building pressure to within the adjustable, specified dead band that shall be adjustable at the human interface panel.
- D. Provide Ventilation Override Mode. With the ventilation override module installed, the unit shall be programmed to transition to up to 5 different programmed sequences for Smoke Purge, Evacuation, Pressurization, Purge, Purge with duct control sequence and Unit off. The transition shall occur when a binary input on the VOM is closed (shorted); this would typically be a hard wired relay output from a smoke detector or fire control panel.

## 2.12 OUTDOOR AIR SECTION

- A. Provide 0-100 Percent Modulating Economizer. Shall be operated through the primary temperature controls to automatically utilize OA for "free" cooling. Automatically modulated return and outside air dampers shall maintain proper temperature in the space. Economizer shall be equipped with an automatic lock out when the outdoor high ambient temperature is too high for proper cooling.
- B. Minimum position control shall be standard and adjustable at the Human Interface Panel or with a remote potentiometer or through the building management system. A spring return motor shall ensure closure of OA dampers during unit shutdown or power interruption. Mechanical cooling shall be available to aid the economizer mode at any ambient.
- C. Provide demand control ventilation (DCV) system fully integrated with unit economizer. Controller shall minimize fresh air intake during periods of low occupancy based on parts per million space CO2 in response to a customer defined parts per million CO2 setpoint. CO2 setpoint, and minimum DCV fresh air damper position shall be programmable at the human interface, or building management system.
- D. Provide Outside Air Measurement. A factory mounted airflow measurement station (Traq™) shall be provided in the outside air opening to measure airflow. The airflow measurement station shall measure from 40 cfm/ton to maximum airflow. The airflow measurement station shall adjust for

temperature variations. Measurement accuracy does not exceed 10% at minimum airflow and decreases to less than 5% at higher airflows, meeting requirements of LEED IE Q Credit 1 as defined by ASHRAE 62.1-2007.

- E. Provide Economizer Control with Reference Enthalpy. Economizer control option shall include an outdoor enthalpy sensor to compare the total heat content of outdoor air to a locally adjustable setpoint. The setpoint shall be programmed at the user interface to determine if the outdoor enthalpy condition is suitable for economizer operation.

#### 2.13 DAMPERS

- A. Provide Low Leak Economizer Dampers. Low leak dampers shall be provided with rolled stainless steel jamb seals to the sides of the damper assembly. Low leak economizer dampers shall have a leakage rate of 10 cfm/sq ft or less tested in accordance with AMCA Standard 500.
- B. Fault Detection and Diagnostic (FDD) control shall also be provided with Low Leak Economizers. FDD control shall monitor the commanded position of the economizer compared to the feedback position of the damper. If the damper position is outside +/- 10% of the commanded position, a diagnostic shall be generate
- C. Provide Ultra Low Leak Economizer Dampers. Economizer return and outside air dampers shall be provided with chlorinated polyvinyl chloride gasketing added to the damper blades and rolled stainless steel jamb seals to the sides of the damper assembly. The economizer shall have a functional life of 60,000 opening and closing cycles. Dampers shall be AMCA 511 Class 1 certified with a maximum leakage rate of 4 cfm/sq-ft at 1.0 inch wg. pressure differential thus meeting requirements of ASHRAE 90.1-2013, California Title 24-2013, and IECC-2012.
- D. Fault Detection and Diagnostic (FDD) control shall also be provided with ultra low leak economizers. FDD control shall monitor the commanded position of the economizer compared to the feedback position of the damper. If the damper position is outside +/- 10% of the commanded position, a diagnostic shall be generated.

#### 2.14 ROOF CURB ADAPTOR

- A. Provide factory supplied roof curb adaptor for connection to existing to remain roof curbs.
- B. Contractor is responsible for final measurements and field verification of dimensions before or after demolition of existing units occur.
- C. Curb Adaptors shall be constructed of heavy gauge zinc coated steel with supply and return air gasketing. Ship knocked down and provide instructions for easy assembly.
- D. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines for rooftop equipment support.

- E. Contractor to coordinate condensate drain piping and trap height with the existing to remain roof curb and new adaptors. Contractor shall consult trap height with internal static pressure requirements and verify with roof top manufacturer. Condensate piping shall be routed per the documents to nearest roof drain.

## 2.15 Controls

- A. All unit controls shall have compatibility, via BACNET, to the existing building automation system. The contractor shall verify and coordinate with the Owner for all requirements before purchase of new units to eliminate any compatibility issues of integration between the new units and existing building interface. Owner will source separate county approved controls contractor to integrate the RTU controls (from on board controller) to the existing BAS system established in the existing buildings. The units shall be provided with a fully functional controls setup from the factory prior to the county controls contractor taking over responsibility. It is the responsibility of the contractor to coordinate and verify the factory units and permissions to ensure county contractor is receiving a fully compatible system for integration.
- B. Provide Symbio 800 Controls for new RTUs. The controller shall be an application-specific, programmable controller that is factory installed and designed to control packaged HVAC equipment. A 7" user interface features a touch-sensitive color screen that provides facility managers with at-a-glance operating status, performance monitoring, scheduling changes and operating adjustments. Other advanced features include automated controller backup on SD card and optional features such as secure remote connectivity, wireless building communications, mobile device connectivity and custom programming and expandable I/O
- C. Provide Power Meter. Factory installed power meter shall measure unit energy usage to 0.2% accuracy (ANSI C12.20) and communicate through the Symbio 800 controller enabling viewing through user interface or building automation system.
- D. Provide Rapid Restart. Option shall provide immediate start up upon power failure. A backup generator shall be required on site before unit start up. Rapid Restart shall begin immediately after recovery from a power loss and work by restarting the compressors and supply fan quickly to provide full cooling within two to three minutes.
- E. Provide Multi Zone Variable Air Volume (Discharge Air Temperature). Option shall provide all necessary controls to operate a VAV rooftop from the discharge air temperature, including discharge air microprocessor controller and discharge air sensor. The controller shall coordinate the economizer control and the stages of cooling with discharge air temperature reset capabilities. Includes factory installed and tested VFDs to provide supply fan motor speed modulation.
- F. All communications shall support standard BACnet® communication protocol through a RS485, two-wire communication link or BACnet®/IP.

- 2.16 ADD Alternate #1 – Bi Polar Ionization (Supply Duct Mounted in each supply riser)
- A. Basis of Design is Phenomenal Aire Series “C” Universal (C20).
  - B. Unit shall be direct insertion type and duct mountable.
  - C. Electrical shall be 5 watts at 110 volts, per unit.
  - D. 4 units per RTU. Contractor to verify final selections and model with manufacturer for total airflow.
  - E. Pressure drop shall be minimized and not greater than 0.05” Wg.
  - F. Control head shall be mounted external to supply duct and placed on the discharge supply ductwork prior to any duct split or branch ducts.
  - G. Controls shall coordinate with RTU control panel for airflow verification prior to energizing.
  - H. Capacity shall be a minimum of 190 million ions/cc/sec per inch of insertion tube.
  - I. Provide unit with minimum of 3 year factory warranty.
  - J. Tube shall be made of carbonized resin or carbon fiber.
  - K. Other acceptable manufacturer is Atmos Air.
  - L. Capacity of unit shall be verified with the final purchased maximum airflow of the new units.
  - M. Contractor to provide weatherproof disconnect switch for each system provided for each RTU. Coordination with electrical documents for electrical circuiting.
- 2.17 ADD Alternate #2 – UV Light Section (Installed in Unit)
- A. Basis of Design is Lumalier model AR95.
  - B. Unit shall mounted directly in unit after cooling coil.
  - C. Electrical shall be 120 volts.
  - D. Confirm final dimensions and bulb number and array with approved roof top manufacturer. For basis of design RTU unit shall be a 2 row 5 bulb array.
  - E. Provide and coordinate external junction box with RTU manufacturer and other trades.
  - F. Bulbs shall be 95 watts. (Contractor to provide 1 full set of additional bulbs with purchase of new system for each RTU.)
  - G. Door switch shall be provided with each unit.

- H. PCO reduction kit shall be provided for each unit.
- I. Light system framing shall be constructed of aluminum.
- J. Bulb life shall be no less than 18 months.
- K. Unit shall be certified by ASHRAE TC 2.09 and EPA EST. No. 91347-TN-001.
- L. Provide unit with minimum of 5 year factory warranty.
- M. Contractor to provide weatherproof disconnect switch for each system provided for each RTU. Coordination with electrical documents for electrical circuiting.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Verify that roof is ready to receive work and opening dimensions are as measured in the field by the mechanical contractor. Before start of demolition of existing unit, contractor to verify the existing to remain roof curb dimensions to ensure the new roof curb adaptor will fit per manufacturer's requirements.
- B. Verify that proper power supply is available.

#### **3.2 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Mount units on factory built roof mounting frame providing watertight enclosure to protect ductwork. Install roof mounting curb level.
- C. Contractor to verify and coordinate curb adaptor dimensions with existing to remain roof curb on roof prior to installation of new units.

#### **3.3 MANUFACTURER'S FIELD SERVICES**

- A. OEM Startup is performed by factory trained and authorized service technicians confirming equipment has been correctly installed and passed specification checklist prior to equipment becoming operational.

## SECTION 260500

### ELECTRICAL GENERAL PROVISIONS

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. Provide complete, tested and fully functional electrical systems as shown on the Drawings and as specified herein.
- B. Electrical equipment and installed systems shall be suitable for the intended application, shall be safe for the intended use, shall be rated for the available fault current, and shall conform to local building codes and statutory requirements.

##### 1.2 Related Documents

- A. The Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Electrical requirements specified in this Section apply to electrical equipment and materials described in other Sections of Division 16.

##### 1.3 Scope OF WORK

- A. The work includes, but is not limited to, the following:
  - 1. Basic electrical materials and methods
  - 2. Grounding and bonding
  - 3. Electrical identification
  - 4. Wire and cable
  - 5. Raceways, boxes, and fittings
  - 6. Enclosed switches and circuit breakers
  - 7. Enclosed controllers
  - 8. Panelboards
  - 9. Fire Alarm
  - 10. Removal and/or relocation of existing equipment
  - 11. Field wiring for equipment provided under other Sections of the Specification
  - 12. Thorough cleaning of all equipment prior to energization
  - 13. Acceptance testing of all equipment installed under this Section
  - 14. Protection of all equipment under this Division until the final acceptance of the job
- B. Coordinate Division 16 requirements with work in other Divisions.

- C. Submit preconstruction submittals, shop drawings, product data, samples, design data, test reports, certificates, manufacturer's instructions, manufacturer's field reports, operation and maintenance data, closeout submittals and other specified documents to the Engineer for review and approval as described in Division 1, in this Section, and in other Sections of Division 26.
- D. Perform electrical acceptance tests described in other Division 16 Sections (Part 3).
- E. The following principal items of work will be performed under other Sections unless otherwise noted:
  - 1. Finish painting of all exposed raceways, boxes, hangers, apparatus, etc., except as otherwise specifically mentioned herein.
  - 2. Cutting and patching referred to in Division 1.
  - 3. Motors for mechanical equipment will be furnished under other Divisions.
  - 4. Automatic temperature control system design, installation, and raceways, boxes & fittings, and control wiring and signal cable, is included in Division 15.

#### 1.4 PROJECT CONDITIONS

- A. Ambient temperature, humidity, and elevation ranges: Equipment other than transformers shall be rated for continuous operation at full rated load without derating, under the following conditions:
  - 1. Ambient Temperature: 0 to 40 deg C.
  - 2. Humidity: Less than 90 percent (non-condensing).
  - 3. Altitude: Not exceeding 3300 feet (1000 m).

#### 1.5 Definitions

- A. In addition to the Definitions in Specification Division 1, the following definitions apply to Division 16:
  - 1. AHJ: The statutory Authority Having Jurisdiction as defined in NEC Article 100 for enforcement of legally required compliance to local codes, standards, and ordinances.
  - 2. ANSI: American National Standards Institute
  - 3. AEIC: Association of Edison Illuminating Companies
  - 4. ASQ: American Society for Quality
  - 5. AWG: American Wire Gauge
  - 6. CFR: Code of Federal Regulations
  - 7. Cable: an assembly of insulated conductors
  - 8. Control panel: an electrical enclosure housing control logic devices and an operator control interface
  - 9. Contract: as used in the Electrical Specification, includes all Contract documents including Specifications and Appendices, Drawings, Addenda, and Change Orders
  - 10. ICEA: Insulated Cable Engineers Association

11. Equipment: a general term including materials, fittings, devices, appliances, fixtures, apparatus, and the like, used as part of, or in connection with, an electrical installation (OSHA Section 29 CFR 1910.399(46) definition)
12. FM: Factory Mutual, Inc.
13. Field wiring: on-site installation of raceways & conductors to connect equipment in accordance with approved drawings
14. Field test: electrical test carried out on-site
15. Fail-safe: selection of control devices and contacts in a manner which results in safe shutdown of the equipment whenever one of the following events occurs:
  - a. Loss of remote control RUN command (normal configuration: contacts close to run equipment)
  - b. Intentional and unintentional disconnection of device (normal configuration: contacts open to shut down equipment)
  - c. High contact resistance or high resistance connection
  - d. Loss of 4-20mADC signal
  - e. Definite-time sequence takes too long, e.g., reduced voltage motor starter fails to make transition from START mode to RUN mode after a reasonable time
  - f. Defined sequence does not occur, e.g., there is no flow from a motor driven pump within a reasonable time after the motor starter contactor is energized.
16. Furnish and install: same as "Provide" below.
17. Functional testing: verification of the satisfactory performance of control logic, with due attention to equipment protective devices, for example, overload relays, temperature switches, pressure switches, flow switches, and similar devices, under actual operating conditions
18. HV: high voltage, operating voltage over 600V (NEC definition)
19. IEEE: Institute of Electrical and Electronics Engineers, Inc.
20. ISO: International Standards Organization
21. Lineup: with respect to switchgear, switchboards, and motor control centers, a contiguous group of vertical sections with common main busbars, and including bus tie breaker sections and control sections
22. LV: low voltage, operating voltage under 600V (NEC definition)
23. Megger: insulation tester with megohm scale
24. NEC: NFPA 70, the National Electrical Code
25. NETA: InterNational Electrical Testing Association, Inc.
26. NICET: National Institute for Certification in Engineering Technologies
27. NFPA: National Fire Protection Association
28. NRTL: Nationally recognized testing laboratory as defined in 29 CFR 1910.7 as it applies to testing and inspecting for safety in the workplace (OSHA definition)
29. Nonconformity: The nonfulfillment of a specified requirement (ASQ definition)
30. "Or approved equal": proposed "equal" product shall be in conformance with all specified requirements, shall be equivalent in materials of construction to specified manufacturers' products, shall have equal or superior performance in the conditions anticipated for use of the product in this project, and shall be approved by the Engineer
31. OSHA: Occupational Safety and Health Act
32. Panel: with respect to circuit breaker and fuse power distribution centers, panel is equivalent to "distribution board", e.g., lighting panel; with respect to control panels,

- refers either to the entire control panel itself or to a steel plate used for mounting devices inside the control panel
33. Provide: Throughout the Specification, use of this term includes project administration, quality assurance, human resources, tools & equipment, logistics and scheduling, submittals of shop drawings & samples for approval, managing suppliers, purchasing, manufacturing, factory testing, release for shipment, packing, delivery, storage, submittal of coordinated & dimensioned installation drawings for approval, installation, surface preparation & finishes, site testing, startup & commissioning, on-site supervision by equipment manufacturers' representatives, spare parts & tools, Operations and Maintenance (O&M) Manuals, training, guarantees and warranties, other work described in individual Sections of the Specification, and the Contractor's duties, responsibilities, risks, and liabilities under the Contract.
  34. Punch list: document containing detailed descriptions of non-conformities
  35. Quality: conformance to specified requirements.
  36. RMS: root mean square
  37. Raceways: cable ladder and tray, conduit, duct, wireway, and associated boxes and fittings which enclose, support, and protect wires and cables
  38. Shop drawings: a complete package of manufacturer's equipment drawings, bill of materials, catalog data sheets, performance curves, calculations, and other data provided to demonstrate conformance to the equipment specification
  39. Substitution: an alternative, nonconforming product proposed by the Contractor in lieu of a specified, conforming product
  40. Substantial Completion: an electrical system may be considered substantially complete when the equipment has passed the specified tests required prior to energization, has been energized, has passed the Electrical Acceptance Tests, and all related Specification requirements have been met except for well-defined minor items which, in the opinion of the Engineer, may be repaired or replaced prior to Final Acceptance without adversely affecting process performance.
  41. Terminal box: an electrical enclosure containing labeled terminal blocks for connection of wiring
  42. UL: Underwriters Laboratories, Inc.
  43. VFC: variable frequency controller
  44. VFD: variable frequency drive, the combination of VFC and inverter-duty motor that drive mechanical loads using the principle of variable frequency motor control
  45. Wiring: conductors and connections to equipment terminals. 'Wiring' and 'cabling' shall be considered equivalent terms. Fiber optic cables shall be included in the scope of electrical wiring.

#### 1.6 Reference standards

- A. Notwithstanding revision dates shown in this and other Sections of Division 16, the codes and standards applicable to this project shall be those in effect at the time of bid submittal, except for NFPA 70 NEC, which shall be the version acceptable to the AHJ.

1.7 Quality Assurance

- A. In consultation with the equipment and materials Suppliers, the Contractor shall prepare and submit a Compliance Statement as described in "SUBMITTALS" below with each submittal requiring approval.
- B. The Engineer's approval of a submittal shall not relieve the Contractor of any Contractor responsibilities under the Contract. Approval of a submittal that is incomplete, or one that has nonconformities that are not described in the Compliance Statement that is specified to be included with each submittal, followed by the discovery of unapproved nonconformities, will result in replacement of the non-conforming items at no additional cost to the Owner. Substitutions require the approval of the Engineer.
- C. Manufacturers of electrical equipment shall have quality certification to ISO 9000:2000 or an equivalent Quality Management System acceptable to the Engineer.
- D. Equipment, materials, and installation shall conform to NEC requirements and shall be NRTL-listed and labeled.
- E. On-site testing prior to energization and electrical acceptance testing shall be performed as specified in other Sections.
- F. Manufacturers, manufacturer's representatives, subcontractors, supervisors, installers, and testing agencies shall have qualifications and experience as described in other Sections of the Specification. Qualifications and experience submittals for firms and individuals shall be submitted, re-submitted, or updated whenever requested by the Owner's Representative.

1.8 SAFETY IN THE WORKPLACE

- A. Electrical equipment and materials, and the Contractor's installation practices, shall conform to the following:
  - 1. Current edition of OSHA sections of the Code of Federal Regulations (CFR): Part 29 CFR 1910 for General Industry and Part 19 CFR 1926 for Construction Activities
  - 2. NFPA 70, the National Electrical Code
  - 3. Current edition of NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces
- B. These regulations and standards impose obligations on equipment manufacturers to obtain NRTL certification, listing, and labeling to comply with OSHA (Occupational Safety and Health Act) and Department of Labor regulations.
- C. All electrical equipment for which NRTL test procedures have been established shall be certified, listed, and labeled, or otherwise determined to be safe for its intended use, by a NRTL. The absence of a specific reference to NRTL-listing in other Sections shall not relieve the Contractor of the requirement to provide NRTL-listed equipment, and to obtain certification as

required by the AHJ in cases where NRTL listing and labeling is not a manufacturer's standard offering for a particular product.

- D. Equipment shall not be modified in any manner adversely affecting safety for the intended use, nor shall any equipment be modified on-site without the approval of the manufacturer.
- E. Equipment sound levels shall not exceed limits established by reference standards and local regulations. In the absence of reference standards and local regulatory requirements, sound pressure levels shall not exceed 85 dB (A) measured three feet from the equipment.
- F. Equipment with moving parts shall be fully guarded in compliance with OSHA rules and regulations.

#### 1.9 INSPECTIONS BY THE AHJ

- A. The Contractor shall make arrangements for electrical inspection of the project by the AHJ. Upon completion of the work, final certificate of approval documents shall be submitted to the Engineer for forwarding to the Owner. This certificate shall be submitted prior to request for final payment. The Contractor shall pay all fees required for inspection.

#### 1.10 Workmanship and Materials

- A. Materials and equipment shall be new and undamaged, shall be marked by the manufacturer, and shall be delivered to the construction site in the original factory packaging.
- B. Materials and equipment shall be installed in accordance with the Drawings, the Specification, and the manufacturer's installation, operation, and maintenance instructions. In the event of apparent conflicts or discrepancies, the Engineer shall be informed of the apparent conflict or discrepancy in writing, and will instruct the Contractor how to proceed.

#### 1.11 RESOURCES AND CONSTRUCTION SCHEDULE

- A. The Contractor shall provide sufficient resources, including qualified and experienced project managers, electrical engineers, superintendents, technicians, supervisors, electricians, tools and construction equipment to complete the electrical work in accordance with the activity durations and sequences shown on the Construction Schedule for this project.
- B. The construction schedule shall include the following activities and milestones, in realistic sequence, for each switchgear lineup, transformer, switchboard, motor control center, generator set, and fuse or circuit breaker panelboard in each building:
  - 1. Review of shop drawings
  - 2. Approval of shop drawings (milestone)
  - 3. Request for release of shipment documentation
  - 4. Shipping

5. Room ceiling, wall, and floor finishing complete (ready for equipment installation)
6. Tests on completion of installation (prior to energization)
7. Energization (milestone)
8. Functional testing
9. Acceptance testing
10. Installation and testing (milestone)

C. The construction schedule shall include the following activities and milestones, in the following sequence, for electrical raceways and wiring in each building and structure:

1. Review of Contractor's dimensioned layout and coordination drawings
2. Approval of Contractor's dimensioned layout and coordination drawings (milestone)
3. Materials delivery to site (milestone)
4. Room ceiling, wall, and floor finishing complete (ready for exposed raceway installation)
5. Surface raceway installation
6. Wire & cable installation
7. Tests on completion of installation (prior to energization)
8. Wire and cable testing complete (milestone)

#### 1.12 CONTRACT DRAWINGS

A. The Electrical Drawings provide scaled layouts of representative equipment and key building dimensions, for example, structural gridlines, but do not include "approved for construction" dimensions for equipment.

#### 1.13 Coordination of Work

A. Work under this Division shall be performed in conjunction with the work of other trades. Coordinate electrical installation work with the overall construction schedule. Examine the plans and specifications prior to commencement of work and become familiar with all phases of work involved prior to commencing installation work.

B. The Contractor shall be responsible for coordinating dimensions of equipment and working clearances in accordance with NEC, and in all cases bring to the attention of the Engineer any discrepancies on the plans and in the specifications prior to installation. Any work that installed without proper coordination shall be removed and reinstalled at the Contractor's expense. The layout for sleeves, chases, openings, etc., must be arranged prior to construction in order to prevent unnecessary cutting. Examine Architectural drawings for doors swings, countertop heights, built-in furniture and casework, and other factors affecting electrical outlet locations prior to roughing-in raceways, boxes, fittings, and outlets.

C. Control and signal wiring requirements shall be coordinated with Division 15000.

- D. Coordinate a 120/240V all work to obtain electrical service from utility company to insure a complete installation, this will include all conduit, wire, ductbanks, CT cabinets, pads and meter.

#### 1.14 COORDINATION DRAWINGS

- A. Following approval of equipment shop drawings, the Contractor shall create dimensioned electrical equipment layout drawings, showing the relationships of approved electrical equipment with the building structural and architectural components, walls, floors, ceilings, doors, windows, louvers, access hatches, concrete equipment pads, and seismic anchors and bracing. One set of these Coordination Drawings shall be maintained at the construction site throughout the construction phase.

#### 1.15 Codes and Standards

- A. All equipment and materials shall be manufactured, tested, and installed in accordance with the National Electrical Code (NEC) and all applicable portions of local codes, in accordance with the requirements of the AHJ.
- B. In addition, work shall be in accordance with the versions of the following referenced standards in effect at the time of bid opening:
  1. American Association for Laboratory Accreditation (A2LA)
  2. American Society for Testing and Materials (ASTM)
  3. American National Standards Institute (ANSI)
  4. Americans with Disabilities Act (ADA)
  5. Code of Federal Regulations (29 CFR 1903, 1910, and 1926)
  6. Factory Mutual Engineering & Research (FME&R)
  7. Illuminating Engineering Society of North America (IESNA)
  8. Insulated Cable Engineers Association (ICEA)
  9. International Organization for Standardization (ISO)
  10. National Electrical Manufacturers Associates (NEMA)
  11. Institute of Electrical and Electronic Engineers (IEEE)
  12. National Fire Protection Association (NFPA)
  13. Occupational Safety and Health Act (OSHA)
  14. Underwriters Laboratory, Inc. (UL) and other NRTL standards and test procedures

#### 1.16 Submittals

- A. Submittals shall conform to requirements described in Division 1 Section "Submittal Procedures".
- B. Compliance Statement: with each submittal, include a Compliance Statement listing each Specification Section, and Part 1, 2, and 3 Sub-Sections, stating, paragraph-by-paragraph, compliance with the Specification, each minor nonconformity that is within the intent of the

Specification, and proposed nonconformities. Provide short description of minor nonconformities, and detailed explanation of other nonconformities.

C. Submittal Format

1. Each submittal shall be accompanied by a transmittal letter showing the submittal category and Specification Section reference number(s). Submittals shall be 3-hole punched and neatly bound.
2. Submittals shall have a complete Table of Contents with tabs corresponding to the Table of Contents headings.
3. Submittal transmittal letters shall clearly identify the reason for submittal, e.g., for approval, as manufactured, or as-built / record.
4. Each page of each submittal shall be numbered. Page numbers shall be listed on the Table of Contents. Content shall be printed on 8½ x 11 inch paper, or 11 x 17 paper (folded). Larger size drawings shall be folded and placed in labeled individual clear plastic pockets.
5. Product Data shall be clearly marked to show which items are proposed for this project. Information that does not apply to this project shall be crossed out.

D. Submittal Categories

1. SD-01 Preconstruction Submittals, including proposed substitutions, supplier and manufacturer qualifications and experience, construction scheduling, preliminary harmonics analysis for variable frequency controllers
2. SD-02 Shop Drawings, including equipment drawings, seismic bracing details, and Coordination Drawings
3. SD-03 Product Data, marked to indicate precisely which items are proposed for this project
4. SD-05 Design Data, including manufacturer's design calculations
5. SD-06 Test Reports, including prototype tests, factory tests, field tests, acceptance tests, and functional tests
6. SD-11 Closeout Submittals, including black line paper copy of Record Drawings marked in red illustrating changes during construction
7. Spare Parts and Special Tools List

E. In the absence of contradictory instructions in Division 1 Section "Submittal Procedures", Shop Drawings and Coordination Drawings shall be marked with revision blocks to indicate status as follows:

1. FOR APPROVAL
2. AS MANUFACTURED (incorporates Engineer's comments)
3. AS BUILT / RECORD (incorporates on-site modifications)

F. Product Data Sheets: Submit a list of manufacturers with catalog numbers and product data sheets for the following materials miscellaneous equipment, and obtain approval before the items in question are ordered or installed.

1. Raceways, Boxes, and Fittings
  2. Wire and Cable (600 V and less)
  3. Miscellaneous equipment including enclosed disconnect switches, enclosed circuit breakers, individually mounted combination motor starters, control and pushbutton stations.
- G. Record Drawings: Maintain a full size paper set of "black-line" working drawings throughout the project, and shall carefully record in red ink the actual locations including dimensions to locate each piece of electrical equipment, raceways, boxes, & fittings, and electrical outlets. Upon Substantial Completion of the work, deliver the marked-up set of prints to the Engineer. The Engineer reserves the right to withhold final payment until "As-Built" drawings are received.

## **PART 2 - PRODUCTS AND EXECUTION**

### **2.1 equipment AND MATERIALS**

- A. Provide equipment and materials in compliance with other Sections of Division 16. The requirements in this Section apply to all Sections in Division 16.

### **2.2 ELECTRICAL IDENTIFICATION**

- A. Electrical equipment, raceways, boxes, fittings, wires and cables shall be marked in the field in accordance with Division 16 Section "Basic Electrical Materials and Methods".

### **2.3 ELECTRICAL ENCLOSURES**

- A. In the absence of other specified NEMA enclosure ratings in other Sections of the Specification, electrical enclosures shall have degree of protection ratings suitable for the intended application (e.g., watertight, dust-tight, explosion-proof) and environmental conditions. Electrical equipment enclosures shall have the following NEMA 250 ratings:
1. NEMA 1 or 1A: Enclosures located in clean, dry, indoor Control Rooms and Electrical Rooms shall be NEMA 1 painted steel, except that switchgear, switchboards, and motor control centers in clean, dry electrical rooms shall have foam gaskets on covers and doors (NEMA 1A) to reduce dust intrusion.
  2. Where different enclosure ratings and enclosure materials are specified in other Sections of the Specification, the Contractor shall submit a written request for clarification of the intent of the Specification to the Engineer.
  3. For motor enclosure requirements, refer to Division 15 Section "Electric Motors".

#### 2.4 ELECTROMAGNETIC INTERFERENCE

- A. Power conversion equipment, including variable frequency controllers, battery-powered inverters, computer power supplies, frequency converters, and Uninterruptible Power Supplies, shall be fitted with EMI (electromagnetic interference), RFI (radio frequency interference) and telephone interference filters to limit interference effects on other equipment in the area in accordance with IEEE standards and recommendations applicable to the equipment.

#### 2.5 DISSIMILAR METALS

- A. Dissimilar metals shall not be connected, spliced, or joined except where specifically approved in writing by the Engineer. Copper busbars, aluminum busbars, and copper-to-aluminum busbar connections shall be tin-plated at joints and at cable lugs. Bolted electrical conductor connections shall be made with grade 3 or better plated steel bolts, nuts, and washers. Belleville washers & tin-plated flat washers shall be used at aluminum-to-copper and aluminum-to-aluminum busbar joints.

#### 2.6 WARRANTIES

- A. Warranties for equipment and materials shall conform to Division 2 "Product Requirements".
- B. Provide an on-site parts and labor warranty for a minimum period of one year after Substantial Completion for all equipment and materials. In cases where the manufacturer offers a longer warranty period, the longer warranty period shall apply as described by the manufacturer.
- C. All components of electrical systems that are not fully functional at the time of Substantial Completion shall have warranties extended to provide minimum one year coverage of fully operational equipment unless otherwise approved by the Owner's Representative.

### **PART 3 - EXECUTION**

#### 3.1 DELIVERY AND HANDLING

- A. Equipment delivered to site shall be handled in accordance with manufacturer's recommendations by experienced riggers, crane operators, and fork lift truck operators.

#### 3.2 Storage and Protection of Equipment

- A. All electrical equipment to be used in construction shall be properly stored and protected against the elements. General construction materials shall be stored in covered trailers. Panelboards, emergency lighting, solid state equipment, engine generator shall be stored in a clean, dry, indoor location, under cover, until the building is weathertight and the area where

the equipment is to be installed has been completed to the satisfaction of the Engineer, including completion of overhead work by other trades.

- B. Equipment enclosures exposed to construction damage such as paint spots, spackling, waterproofing, insulation etc. shall be covered and protected against damage.

### 3.3 inspections prior to covering-up

- A. Raceways embedded in concrete or otherwise concealed shall be inspected in the presence of the Engineer's Representative prior to placement of concrete. Sufficient time shall be allowed to make corrections if required.

### 3.4 ON-SITE Inspections and nonconformities

- A. Equipment shall be inspected on delivery to site for physical damage and for compliance with the Specification and approved equipment shop drawings.
- B. Installed equipment, raceways, and wiring shall be inspected on completion of installation for compliance with the Specification and approved installation drawings.
- C. A Punch List will be prepared by the Owner's Representative during inspections and testing, and issued to the Contractor for corrective action.
- D. Conform to Division 1 Section "Contract Closeout".
- E. Repairs, replacement, and other corrective action that requires de-energizing any part of the Electrical Power Distribution and Control System shall be completed prior to the scheduled date for substantial completion of the project.

### 3.5 CUTTING AND PATCHING

- A. Conform to Division 1 Section "Cutting and Patching".

### 3.6 PENETRATIONS and sealing

- A. Sleeves and rectangular openings shall be provided for raceways provided under this Contract, and for raceways for future equipment where future equipment is shown on the Drawings. Sleeves and rectangular openings for the passage of raceways and conductors shall be sealed after the raceways and conductors have been installed. Spare sleeves and rectangular openings shall also be sealed.
- B. Penetration of Waterproof Construction: Coordinate the work to minimize penetration of waterproof construction, including roofs and exterior walls. Where penetrations are necessary, provide sleeves and sealing fittings to make each penetration watertight. Conduit

sleeves and openings shall be sealed watertight with mechanical seals. Watertightness shall not rely on caulking.

- C. Penetration of Fire-Rated Construction: Sleeves and openings in fire-resistant walls and floors for electrical raceways, wires, and cables shall be sealed after installation of the raceways, wires, and cables with NRTL-certified fire penetration seals, sealant, and fire-rated foam filler products to the same degree of fire resistance (e.g., 1, 2, or 4 hours) as the adjacent walls and floors, and to the satisfaction of the AHJ. Where both fire sealing and water sealing is required, mechanical seals with NRTL-listed fire-resistant properties shall be used. Fire sealants shall be compatible with the cable jacket and wire insulation materials. Manufacturer's certification of compatibility shall be provided at the request of the Engineer. For additional requirements, refer to Division 16 Section "Raceways, Boxes, and Fittings".

### 3.7 Alterations and Removal of Existing Work

- A. Conform to Division 1 Section "Selective Demolition".
- B. Where the work specified under this Division connects to the existing electrical systems, the Contractor shall perform all necessary alterations to the existing work as required.
- C. All work performed on the existing electrical systems shall be in accordance with the applicable provisions of the Specification. Visit the project site prior to submitting bids and examine the conditions in which work will be performed. Carefully document all existing conditions pertaining to removal and demolition work.
- D. Contractor shall make connections to existing equipment where indicated on the Drawings.
- E. All existing electrical materials not reused under this Division, and not indicated for handover to the Owner, shall become the property of the Contractor and shall be expeditiously removed from the project site.
- F. While performing connections and alterations to existing electrical work, the Contractor shall take special care to protect all existing equipment from dirt, debris and damage. Damaged equipment shall be replaced at no additional cost to the Owner.
- G. All removal work shall be performed in a neat and workmanlike manner and shall be executed with the least possible disturbance to the building and tenants. The scheduling of all removal work shall be coordinated with other trades and with the Owner's schedule and operation of the building.
- H. Where removal work is performed, the Contractor shall repair all building surfaces damaged by such work. Cut back embedded conduits to 2 inches minimum below finished face of walls, floor, and ceilings, and fill in holes with appropriate patching material. Repair, re-tile, replace (in the case of ceiling panels) or re-paint to match existing adjacent surfaces.

### 3.8 ELECTRICAL SAFETY AND TEST EQUIPMENT

- A. Maintain the following test instruments and calibration certificates less than 12 months old on-site as a minimum:
  - 1. True RMS digital volt-ohm meter with resistance scale
  - 2. Clip-on ammeter with range from 1 to 600 amps
  - 3. 500V DC battery-powered megger insulation tester
  
- B. Provide electrical safety equipment, including personal protective equipment, hot sticks, HV gloves, electrical blankets, test instruments, lighting, ventilation, and instructions in the use of safety equipment, and perform the work under this Contract in accordance with applicable safety rules and regulations. The Contractor's attention is directed to safety issues related to confined spaces as defined in OSHA regulations.
  
- C. One numbered safety lockout padlock with an 'unlawful-to-duplicate' unique key shall be provided for each motor controller. Safety lockouts shall be used during testing and commissioning, and shall subsequently be handed over to the Owner in a lockable sheet metal key cabinet. The safety lockout padlock supplier shall be a specialist supplier with a registered key program.

### 3.9 Cleaning and Painting

- A. Conform to Division 1 Section "Closeout Procedures".
  
- B. After installation and wiring work is completed, all dust and debris shall be removed from the interior and exterior of each electrical equipment enclosure and motor by vacuum-cleaning with circuits de-energized. Do not use compressed air for cleaning. Vacuum cleaner wands and brushes shall be non-conducting. Anti-static protection shall be provided for static-sensitive devices.
  
- C. Clean and remove all rust, scale, oil, grease, and dirt from panelboard enclosures, conduits, pull, junction and terminal boxes, fittings and hangers, leaving surfaces in condition for final surface preparation and painting under Division 9.
  
- D. All ferrous materials that are concealed, or exposed in unfinished areas, including fittings, hangers, junction, pull and terminal boxes, that are not plated or painted with a factory-applied finish, shall be painted under this Section with one coat of zinc-chromate primer and one (1) finish coat of enamel paint approved by the Engineer. Nonferrous materials shall be cleaned only and left unpainted.
  
- E. Equipment furnished with a factory finish coat shall have finish carefully touched-up where it is scratched or otherwise damaged. Touch-up work shall be match the color and type of the original finish.

3.10 INSPECTION AND TESTING ON-SITE

- A. Submit manufacturer-endorsed field test data sheets & procedures for approval, test equipment and materials on-site prior to site visit by manufacturer's factory-trained representative, test equipment on-site under the supervision of the Engineer and the equipment manufacturer's factory-trained representative(s), and submit manufacturer's statement of acceptance of installation prior to energization of equipment. Invite the Engineer's and Owner's representatives to witness field testing.
- B. Electrical equipment shall not be energized without the approval of the Engineer.
- C. A complete certified electrical test report shall be compiled by the electrical testing firm, checked for completeness, and submitted for the record.
- D. The Contractor shall notify all parties whose presence is necessary for the test; and in all cases, the Engineer shall be notified at least one week prior to the actual test.

3.11 LOAD BALANCING

- A. Single phase circuits in single and three-phase fuse and circuit breaker distribution boards and lighting panels shall be balanced initially based on the load calculations. Load currents shall be measured under actual operating conditions, and under conditions described by the Engineer. Circuiting shall be re-arranged as necessary to obtain current balancing within 10% on each busbar.

END OF SECTION

## **SECTION 260519**

### **WIRE AND CABLE**

#### **PART 1 - GENERAL**

##### **1.1 SCOPE OF WORK**

- A. Provide a complete system of wiring and cabling, including wire and cable pulling, splicing, and termination accessories, as shown on the Drawings and in conformance with the requirements in this Section and Division 16 Section "Electrical General Provisions".
- B. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

##### **1.2 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related requirements are also specified in the following Sections:
  - 1. Division 26 Section "Basic Electrical Materials and Methods" for identification requirements.
  - 2. Division 26 Section "Wiring Devices" for wiring devices installed in boxes.
  - 3. Division 26 Section "Grounding" for grounding and bonding.

##### **1.3 DEFINITIONS**

- A. In addition to the definitions in Division Section "Electrical General Provisions", the following definitions apply to this Section:
  - 1. MTW: machine tool wire, 90 deg. C max in dry locations, 60 deg. C max in wet locations
  - 2. THHN: NEC and UL designation for flame-retardant and heat resistant thermoplastic insulation, gas and oil resistant nylon jacketed, suitable for dry locations only, 90 deg. C. max in dry locations
  - 3. THW: NEC and UL designation for flame-retardant, moisture resistant thermoplastic insulation suitable for dry and wet locations, 75 deg. C. max

##### **1.4 REFERENCE STANDARDS**

- A. Comply with the following standards in effect at the time of bid submittal:
  - 1. ICEA P-51-432-1970 Copper Conductors, Bare & Weather Resistant

2. ICEA P-56-520-1984 Cable Tray Fire Test Report (Round Robin Project)
3. ICEA S-58-679-1996 Standard for Control Cable Conductor Identification
4. ICEA S-95-658 / NEMA WC70 Non-Shielded Power Cables Rated 2000 V or Less
5. ICEA T-22-294-1983 Test Procedures for Extended Time-Testing of Wire and Cable Insulations for Service in Wet Locations
6. ICEA T-29-520-1986 Vertical Cable Tray Flame Tests @ 210,000 Btu
7. ICEA T-30-520-1986 Vertical Cable Tray Flame Tests @ 70,000 Btu
8. ICEA T-33-655-1994 Low Smoke, Halogen-Free Polymeric Jackets
9. IEEE 576-2000 Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications
10. UL 62 Flexible Cord and Fixture Wire
11. UL 83 Thermoplastic-insulated Wires and Cables
12. UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors
13. UL 486C Splicing Wire Connectors
14. UL 486D Insulated Wire Connector Systems for Underground Use in Damp or Wet Locations

#### 1.5 SUBMITTALS

- A. Product Data: For each type of product specified herein, including catalog data, technical specifications, evidence of UL listing, and evidence of manufacturer's certification to ISO 9000:2000 or an equivalent quality management system certification acceptable to the Engineer.
- B. Qualifications and experience proposal for the electrical testing firm.
- C. Electrical Acceptance Test reports.
- D. Operation and maintenance data is not required, however, approved shop drawing submittals are required to be included for the record in the Operation and Maintenance Manuals, as described in Division 16 Section "Electrical General Provisions".

#### 1.6 QUALITY ASSURANCE

- A. Source Limitations: Obtain all wire and cable of a particular type through one source from a single qualified manufacturer.
- B. To be a qualified manufacturer, wire, cable, splice and termination components manufacturers shall have accreditation to ISO 9000:2000 or an equivalent quality management system acceptable to the Engineer, and shall offer NRTL-listed and labeled products.
- C. Testing firm shall be qualified as defined by OSHA in 29 CFR 1910.7, shall be a member of the InterNational Electrical Testing Association, shall be acceptable to the AHJ, and shall have supervision as follows:

1. Testing Firm's Field Supervisor: Qualifications and experience for the person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- D. Wire and cable and accessories: Listed and labeled as defined in NEC Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

## PART 2 - PRODUCTS

### 2.1 APPLICATIONS

- A. Refer to Part 3 for wire and cable applications.

### 2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

### 2.3 BUILDING WIRE AND MULTI-CONDUCTOR POWER CABLES

- A. Manufacturers:
1. American Insulated Wire Corp.
  2. Belden Wire and Cable Co.
  3. Cerro Wire and Cable Co., Inc.
  4. Okonite Co.
  5. Pirelli Cable Corp.
  6. Rome Cable Corp.
  7. Southwire Co.
- B. Conductor Material: Copper, solid conductor for No. 10 AWG and smaller, stranded for No. 8 AWG and larger.
- C. Building Wire and Multi-conductor Cable Insulation Types: Type THHN-THWN.
- D. Phase conductors shall be factory color coded or have field applied color-coded tape at each splice and termination in accordance with the following schedules:

240/120V Systems		480/277V Systems	
Phase	Color	Phase	Color
A	Black	A	Brown
B	Red	B	Orange
C	Blue	C	Yellow
N	White	N	Grey
Grd	Green	Grd	Green

#### 2.4 CONTROL AND INSTRUMENTATION WIRE AND CABLE

- A. Manufacturers:
  - 1. Belden Wire and Cable Co.
  - 2. Clifford of Vermont / TVC
  - 3. General Cable Co., Inc.
  - 4. Okonite Co.
  - 5. Rome Cable Corp.
  - 6. Southwire Co.
- B. Control wire: 600V type THWN insulated stranded copper conductors in conduit, minimum size #14 AWG, UL listed and suitable for installation in conduit.
- C. Instrumentation cable for 4-20 mA DC circuits: Polyethylene insulated #18 AWG stranded tinned copper twisted pair, with #20 AWG or larger stranded tinned copper drain wire, overall aluminum-on-mylar shield, with chrome PVC outer jacket. UL listed and suitable for installation in conduit and cable tray.

#### 2.5 Wire AND CABLE CONNECTORS AND SPLICES

- A. Manufacturers:
  - 1. 3M Company, Electrical Products Division
  - 2. AMP Incorporated / Tyco International
  - 3. Burndy
  - 4. Square D
  - 5. Thomas and Betts
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
- C. Wirenuts: Spring type rated for copper wire, sized for the actual number of wires connected.
- D. Splices: Tin-plated copper compression type. Pre-insulated crimp-on connectors may be used for #14 AWG control wires. Long barrel splices shall be used for #1/0 AWG and larger.
- E. Connections at molded case circuit breakers, disconnect switches, and other equipment provided with wire termination lugs: NRTL-listed, suitable for use with the copper wire size to be connected.
- F. Connection lugs: Tin-plated copper compression type with NEMA drilling. Long-barrel lugs shall be used for #1/0 AWG and larger wire.

### **PART 3 - EXECUTION**

#### **3.1 INSPECTION**

- A. Ensure that conduit, and pullboxes are clean and clear of construction debris prior to installation of wire and cable.

#### **3.2 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver wire and cables to construction site and unload in accordance with manufacturer's recommendations.
- B. Store and transport reels in compliance with manufacturer's printed instructions.
- C. Wire and cable ends shall be taped watertight until terminations and splices are completed.

#### **3.3 WIRE AND CABLE APPLICATIONS**

- A. Feeders: Type THHN-THWN, single conductors in raceway.
- B. Branch Circuits: Type THHN-THWN, single conductors in raceway.
- C. Use of Type "19C" cable is acceptable for the conductors and smaller located in ceiling space and stud- built walls.
- D. Fire Alarm Circuits: Type THHN-THWN, in raceway, size and type acceptable to the AHJ and in accordance with the fire alarm system manufacturer's recommendations.
- E. NEC Class 1 Control Circuits: Type THHN-THWN, in raceway.
- F. NEC Class 2 and 3 Control Circuits: Type THHN-THWN, in raceway.

#### **3.4 CABLE LAYING and PULLING**

- A. Feeders and branch circuits shall have a ground conductor.
- B. Each branch circuit shall have an individual neutral conductor. Increasing the neutral conductor size, or "super neutral," is not allowed for multiple branch circuits.
- C. Install cables in accordance with manufacturer's installation instructions, IEEE 576 and AEIC CG5-90.
- D. Run wires and cables in raceways as shown on the Drawings and as specified in Division 16 Section "Raceways, Boxes, and Fittings".

- E. Install no more than 3 phase wires in any feeder or branch circuit conduit.
- F. Use cable manufacturer approved wire pulling lubricant for pulling in wire and cables in conduit. Lubricant shall be UL-listed and shall be suitable for the conductor insulation. Use water-based products.
- G. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- H. Pull wire and cables in accordance with the manufacturer's installation recommendations and requirements, with emphasis on the following:
  - 1. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values
  - 2. Lubricate cables with pulling compound or lubricant that is approved by the cable manufacturer and will not deteriorate conductor or insulation materials of construction.
  - 3. Follow cable manufacturer's recommendations for attaching pulling means to cables, including fish tape, cable, rope, and basket-weave cable grips. Do not attach to cable jacket alone for pulling.
  - 4. Rig pulleys and use pull ropes for pulling cables into raceways.
  - 5. Use tension indicators and electric-motor driven capstan rollers for pulling cables that are too large for pulling by hand.
  - 6. Observe manufacturer's recommendations for the minimum wire and cable bending radius for each type and size of wire and cable provided for this project.
- I. Emergency circuit wires and cables shall be routed and protected from fire and other hazards in accordance with locals codes, in a manner acceptable to the AHJ.
- J. Seal around cables penetrating fire-rated elements according to Division 7 Section "Through-Penetration Firestop Systems."
- K. Identify and color-code conductors and cables according to Division 16 Section "Basic Electrical Materials and Methods."

### 3.5 WIRE AND CABLE CONNECTIONS AND TERMINATIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. For compression lugs and splices, use the lug manufacturer's compression tools and comply with the manufacturer's written instructions.
- C. Control wires shall be run from terminal to terminal without splices, and no more than two wires under a terminal screw.

- D. Splices and terminations shall be insulated with boots, heat shrink tubing, or tape to 600 volts in accordance with the insulation product manufacturer's written instructions.
- E. Feeder taps shall be made with cast bronze 2-bolt or 4-bolt connectors with built-in conductor spacer, suitable for the run and tap conductor sizes. Split bolt connectors shall not be used unless approved by the Engineer.
- F. Wiring at Device Outlets: Install conductor at each outlet, leaving 8 inches of wire coiled in the box for connection to wiring devices. Wiring devices that are suitable for solid wire only shall be pigtailed to stranded wire with solid wire 6 inches long using wirenuts.
- G. Install a green insulated NEC-sized grounding jumper from a green ground screw in the outlet box to the receptacle or switch green ground screw.
- H. Wiring to terminals at transformers and busbars shall be connected with tin-plated copper compression connectors and insulated for 600 volts with tape, boots, or heat-shrink tubing rated for the temperature specified by the equipment manufacturer. Two hole lugs shall be used for power cable terminations # 1/0 AWG and larger.
- I. Building wire connections to flexible motor leads shall be made with compression connectors bolted back-to-back with silicone-bronze bolts and insulated for 600 volts. For motors with busbar connections, connections shall be made with tin-plated copper lugs and silicone bronze bolts.
- J. Multi-conductor cables shall be installed and terminated in accordance with the cable manufacturer's installation instructions. Armored and metal clad cables shall be terminated with fittings suitable for grounding.

### 3.6 ELECTRICAL ACCEPTANCE TESTING

- A. Testing: Owner will engage a qualified testing agency to perform the following field quality-control testing:
- B. Testing: Engage a qualified testing agency to perform the following field quality-control testing:
- C. Testing: Perform the following field quality-control testing:
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
- D. Test Reports: Prepare a written report to record the following:
  - 1. Test procedures used.
  - 2. Test results that comply with requirements.
  - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

ANNE ARUNDEL CO. DEPARTMENT OF PUBLIC WORKS  
HERITAGE COMPLEX - RTU REPLACEMENT  
County Contract No. C537896  
FINAL Submission

RMF Engineering, Inc.  
RMF No. 121004.A0  
September 22, 2023

END OF SECTION

## SECTION 260523

### GROUNDING AND BONDING

#### PART 1 - GENERAL

##### 1.1 SCOPE OF WORK

- A. Provide a complete system of grounding electrodes, grounding electrode conductors, main bonding jumpers, equipment grounding conductors, and bonding in accordance with NEC requirements, in conformance with this Section and Division 16 Section "Electrical General Provisions", and as shown on the Drawings.

##### 1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
  - 1. Division 16 Section "Wire and Cable" for wire connector and equipment grounding conductor requirements.
  - 2. Division 16 Section "Raceways, Boxes, and Fittings" for grounding bushing requirements.

##### 1.3 SUMMARY

- A. This Section includes requirements for grounding electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

##### 1.4 DEFINITIONS

- A. Refer to NEC for definitions of grounding terms used in this Section.

##### 1.5 qualifications

- A. Manufacturer's Factory Qualifications: Manufacturing facilities shall have accreditation to ISO 9000:2000 or an equivalent quality management system acceptable to the Engineer. The manufacturing company shall be listed in a published NRTL directory of companies offering NRTL-listed and labeled products.

- B. Testing Firm Qualifications: An independent firm, with experience and capability to conduct specified tests, and is a member company of NETA or is an NRTL as defined by OSHA in 19 CFR 1910.7, acceptable to the AHJ.
- C. Testing Firm's Field Supervisor Qualifications: person currently certified by NETA or NICET to supervise on-site testing specified in Part 3.

## 1.6 REFERENCE STANDARDS

- A. Comply with the following standards:
  - 1. IEEE 80-1986 Interpretation: Guide for Safety in AC Substation Grounding
  - 2. IEEE 80-2000 Guide for Safety in AC Substation Grounding
  - 3. IEEE 81.2-1991 Guide for Measurement of Impedance and Safety Characteristics of Large Extended or Interconnected Grounding Systems (Part 2)
  - 4. IEEE 81-1983 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)
  - 5. IEEE 118-1978 (R1992) Standard Test Code for Resistance Measurements
  - 6. IEEE 142-1991 Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)
  - 7. IEEE 1100-1999 IEEE Recommended Practice for Powering and Grounding Electronic Equipment. (IEEE Emerald Book)
  - 8. IEEE C57.13.3-1983 (R1990) Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases
  - 9. IEEE C57.13.3-1983 (R1991) Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases
  - 10. NFPA 70 The National Electrical Code

## 1.7 SUBMITTALS

- A. Product Catalog Data Sheets: For each type of product indicated.
- B. Product Data: For the following:
  - 1. Grounding electrode conductors
  - 2. Mechanical grounding connector products
- C. Qualification Data: For firms and persons specified in "Qualifications" in Part 1 of this Section.
- D. Acceptance Test Reports: Submit written test reports to include the following:
  - 1. Test procedures used.
  - 2. Test results that comply with requirements.
  - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

## **PART 2 - PRODUCTS**

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with the requirements described in this Section, provide products by one of the listed manufacturers in the Sub-Sections below.
1. Grounding electrode connectors:
    - a. Copper compression type:
      - 1) Dossert Corp.
      - 2) Framatome Connectors / Burndy
      - 3) Harger Lightning and Grounding, Inc.
      - 4) ILSCO
      - 5) O. Z. Gedney / EGS Electrical Group
      - 6) Panduit Corp.
      - 7) Robbins Lightning, Inc.

### 2.2 Grounding ELECTRODE conductors

- A. Grounding Electrode Conductors: Solid for #6 AWG and smaller, Class A stranded for #4 AWG and larger, bare copper conductor, size(s) as indicated on the Drawings. Class B stranding is not acceptable for conductors in contact with earth.
- B. Comply with the following:
1. Solid Conductors: ASTM B 3.
  2. Assembly of Stranded Conductors: ASTM B 8.
  3. Tinned Conductors: ASTM B 33.

### 2.3 Bonding jumpers

- A. Main Bonding Jumpers: copper or tin-plated copper, furnished with the service equipment by the equipment manufacturer. Panelboards up to 225 amps may use a bonding screw.
- B. Equipment Bonding Jumpers: insulated copper building wire, sized to match the largest equipment grounding conductor in the associated conduits.
- C. Bonding Jumper: insulated copper wire, protected by conduit where exposed to physical damage
- D. Electrical and telephone room ground bus: Bare, annealed copper bars of rectangular cross section, with insulators.

2.4 equipment grounding CONDUCTORS

- A. Equipment Grounding Conductors: Insulated building wire in accordance with Division 16 Section "Wire and Cable". #6 AWG and smaller shall have green insulation, #4 AWG and larger shall have green insulation or shall be marked with green tape at each end.

2.5 CONNECTOR PRODUCTS

- A. Comply with IEEE 837 and UL 467. Products shall be NRTL-listed and shall be suitable for use for specific types, sizes, and combinations of conductors and connected items.
- B. Bolted Connectors: Bolted-pressure type silicone bronze connectors for test joints at ground rods with test (access) wells, and two-hole long barrel tin-plated copper compression type at equipment busbars and bonding connections to structural steel.
- C. Wirenuts: for use only for branch circuit wiring in switch and receptacle outlet and junction boxes containing #10 AWG and smaller wires.

**PART 3 - EXECUTION**

3.1 INSTALLATION – General

- A. Install grounding electrode conductors, equipment grounding conductors, equipment bonding jumpers, and bonding, in accordance with NEC requirements and as shown on the Drawings.
- B. Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
  - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
  - 2. Make connections with clean, bare metal at points of contact.
  - 3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.2 INSTALLATION: GROUNDING ELECTRODE CONDUCTORS

- A. Grounding Electrode Conductors: Route along shortest and straightest paths possible, unless otherwise indicated on the Drawings. Avoid obstructing access or placing conductors where subject to strain, impact, or damage.
- B. Connect grounding electrode conductor(s) to the service transformer enclosure ground and equipment as shown on the Drawings.

- C. Bond grounding electrode conductors in conduit to each end of each conduit run using a bronze conduit-to-wire grounding fitting.

### 3.3 INSTALLATION: EQUIPMENT GROUNDING CONDUCTORS

- A. Provide separate insulated equipment grounding conductors in raceways, boxes, and fittings, as shown on the Drawings and specified herein.
- B. Equipment Grounding Conductor Terminations:
  - 1. At distribution board and panelboard, provide two-hole long-barrel tin-plated compression connector bolted to ground busbar(s) with tin-plated or silicone bronze bolts.

### 3.4 INSTALLATION: EQUIPMENT BONDING JUMPERS

- A. At sheet metal junction, pull and outlet boxes, and electrical enclosures, use conduit hubs bolted to enclosure or double locknuts to bond enclosure to conduit, and connect grounding bushings to equipment grounding conductors. Install equipment bonding jumpers between conduit bushings entering and leaving boxes, using the lugs provided with the grounding bushings.

### 3.5 INSTALLATION: BONDING JUMPERS

- A. Bonding Straps and Jumpers: Install so equipment vibration is not transmitted to rigidly mounted equipment support structure. Use long-barrel tin-plated compression connectors and galvanized steel or silicone bronze hex head cap screws in drilled and tapped holes to bond miscellaneous equipment to equipment grounding conductors.
- B. Bond interior metal piping systems and metal air ducts as shown on the Drawings.
- C. In patient care areas, bond the ground bus of the normal and essential branch circuit panelboards with an insulated copper bonding jumper in conduit. The bonding jumper size shall be the same as the largest panelboard feeder equipment grounding conductor.
- D. Grounding Bus: Install in electrical and telephone equipment rooms as shown on the Drawings.
  - 1. Use insulated spacer; 1 inch space from wall and support from wall 6 inches above finished floor, unless otherwise indicated.

### 3.6 CONNECTIONS

- A. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.
- B. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

### 3.7 ACCEPTANCE TESTING

- A. Testing: Owner will engage a qualified testing agency to perform the following field quality-control testing:
- B. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

END OF SECTION

## SECTION 260529

### BASIC ELECTRICAL MATERIALS AND METHODS

#### PART 1 - GENERAL

##### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

##### 1.2 SUMMARY

- A. This Section includes the following:
  - 1. Supporting devices for electrical components.
  - 2. Electrical identification.
  - 3. Electrical demolition.
  - 4. Cutting and patching for electrical construction.
  - 5. Touchup painting.

##### 1.3 DEFINITIONS

##### 1.4 SUBMITTALS

- A. Shop Drawings: Dimensioned plans and sections or elevation layouts of electricity-metering equipment.
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

##### 1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

## 1.6 COORDINATION

- A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- C. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors."
- D. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
- E. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items before ceiling installation.

## PART 2 - PRODUCTS

### 2.1 SUPPORTING DEVICES

- A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.
- B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.
- C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 9/16-inch- diameter slotted holes at a maximum of 2 inches o.c., in webs.
  - 1. Channel Thickness: Selected to suit structural loading.
  - 2. Fittings and Accessories: Products of the same manufacturer as channel supports.
- D. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.
- E. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
- F. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.
- G. Expansion Anchors: Carbon-steel wedge or sleeve type.

- H. Toggle Bolts: All-steel springhead type.
- I. Powder-Driven Threaded Studs: Heat-treated steel.

## 2.2 ELECTRICAL IDENTIFICATION

- A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.
- B. Raceway and Cable Labels: Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway and cable size.
  - 1. Type: Pretensioned, wraparound plastic sleeves. Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the item it identifies.
  - 2. Type: Preprinted, flexible, self-adhesive, vinyl. Legend is overlaminated with a clear, weather- and chemical-resistant coating.
  - 3. Color:
    - a. Normal power systems – White letters on black background
  - 4. Legend: Indicates voltage.
- C. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- D. Color-Coding Cable Ties: Type 6/6 nylon, self-locking type. Colors to suit coding scheme.
- E. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1/16-inch minimum thickness for signs up to 20 sq. in. and 1/8-inch minimum thickness for larger sizes. Engraved legend in black letters on white background.
- F. Interior Warning and Caution Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145. Preprinted, aluminum, baked-enamel-finish signs, punched or drilled for mechanical fasteners, with colors, legend, and size appropriate to the application.
- G. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

## 2.3 TOUCHUP PAINT

- A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.
- B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

### **PART 3 - EXECUTION**

#### **3.1 ELECTRICAL EQUIPMENT INSTALLATION**

- A. Headroom Maintenance: If mounting heights or other location criteria is not indicated, arrange and install components and equipment to provide the maximum possible headroom.
- B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Right of Way: Give to raceways and piping systems installed at a required slope.

#### **3.2 WIRING INSTALLATION**

- A. Install splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- B. Install wiring at outlets with at least 12 inches of slack conductor at each outlet.
- C. Connect outlet and component connections to wiring systems and to ground. Tighten electrical connectors and terminals, according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

#### **3.3 ELECTRICAL SUPPORTING DEVICE APPLICATION**

- A. Dry Locations: Steel materials.
- B. Selection of Supports: Comply with manufacturer's written instructions.
- C. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of 200-lb design load.

#### **3.4 SUPPORT INSTALLATION**

- A. Install support devices to securely and permanently fasten and support electrical components.
- B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.

- C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
- D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.
- E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.
- F. Install 1/4-inch- diameter or larger threaded steel hanger rods, unless otherwise indicated.
- G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.
- H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.
- I. Simultaneously install vertical conductor supports with conductors.
- J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches from the box.
- K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.
- L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.
- M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:
  - 1. Wood: Fasten with wood screws or screw-type nails.
  - 2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
  - 3. New Concrete: Concrete inserts with machine screws and bolts.
  - 4. Existing Concrete: Expansion bolts.
  - 5. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.
  - 6. Steel: Welded threaded studs or spring-tension clamps on steel.
    - a. Field Welding: Comply with AWS D1.1.
  - 7. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.

8. Light Steel: Sheet-metal screws.
9. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

### 3.5 IDENTIFICATION MATERIALS AND DEVICES

- A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.
- C. Self-Adhesive Identification Products: Clean surfaces before applying.
- D. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color-coding may be used for voltage and phase identification.

### 3.6 FIRESTOPPING

- A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

### 3.7 DEMOLITION

- A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
- C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.
- D. Remove demolished material from Project site.
- E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

### 3.8 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

### 3.9 FIELD QUALITY CONTROL

- A. Inspect installed components for damage and faulty work, including the following:
  - 1. Supporting devices for electrical components.
  - 2. Electrical identification.
  - 3. Electrical demolition.
  - 4. Cutting and patching for electrical construction.
  - 5. Touchup painting.

### 3.10 REFINISHING AND TOUCHUP PAINTING

- A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."
  - 1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
  - 2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
  - 3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

### 3.11 CLEANING AND PROTECTION

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION

## SECTION 260533

### RACEWAYS, BOXES, AND FITTINGS

#### PART 1 - GENERAL

##### 1.1 SCOPE OF WORK

- A. Provide a complete system of raceways, including conduit, fittings, pull boxes, junction boxes, outlet boxes, hangers, supports, and accessories, as shown on the Drawings and in conformance with the requirements in this Section and Division 16 Section "Electrical General Provisions".

##### 1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Raceways, boxes, and fittings components and related requirements are also specified in the following Sections:
  - 1. Division 7 Section "Through-Penetration Firestop Systems" for fire-stopping materials and installation at penetrations through walls, ceilings, and other fire-rated elements.
  - 2. Division 16 Section "Interior Lighting" for special application lighting fixture outlet boxes, including lighting plug-in outlets and ball hanger fittings for fixture stems.
  - 3. Division 16 Section "Basic Electrical Materials and Methods" for supports, anchors, and identification products.
  - 4. Division 16 Section "Wiring Devices" for devices installed in boxes and for floor-box service fittings.
  - 5. Division 16 Section "Grounding and Bonding".

##### 1.3 DEFINITIONS

- A. In addition to the definitions in Division 16 Section "Electrical General Provisions", the following definitions apply to this Section:
  - 1. Clamp-back: spacer used with conduit one-hole strap to provide air gap between surface and conduit
  - 2. EMT: Electrical metallic tubing (NEC definition)
  - 3. Equipment bonding jumper: suitable for connecting sections of conduit used for equipment grounding conductor (see NEC definition)
  - 4. FMC: Flexible metal conduit (NEC definition)
  - 5. ID: inside diameter
  - 6. IMC: Intermediate metal conduit (NEC definition)

7. LFMC: Liquidtight flexible metal conduit (NEC definition)
8. Lighting fixture whips: NEC maximum length of flexible conduit run from junction boxes in fixed raceways to lighting fixtures, to allow movement of the lighting fixtures for initial installation and for maintenance
9. NPT: National pipe thread
10. OD: outside diameter
11. PVC: Polyvinyl chloride
12. RGS: Rigid galvanized steel conduit
13. RMC: Rigid metal conduit (NEC definition)

#### 1.4 REFERENCE STANDARDS

- A. Comply with the following standards in effect at the time of bid submittal:
  1. NEMA Standards applicable to raceways, boxes, and fittings.
  2. UL Standards applicable to raceways, boxes, and fittings. Each raceway, box, and fitting shall be NRTL-listed and labeled.
  3. ANSI and ASTM standards mentioned in this Section and included in the UL and NEMA Standards applicable to raceways, boxes, and fittings.

#### 1.5 ENVIRONMENTAL CONDITIONS

- A. Provide raceways, boxes, and fittings fabricated from materials resistant to corrosion and suitable for the application in the locations where installed, including NEC requirements for installation in "damp", "wet", and hazardous classified areas.

#### 1.6 SUBMITTALS

- A. Product Data: For all raceways, boxes, and fittings proposed to be installed for this project. Mark out inapplicable catalog data.
- B. Detail Drawings for raceway trapeze hangers and bracing: Sealed and signed by a qualified professional engineer.
  1. Design Calculations: Calculate requirements for selecting seismic restraints. Structural calculations for worst case loading of each type of proposed channel assembly, including description of design criteria and industry standard safety factors, stress and deflection analysis with vector diagrams, and bill of materials indicating manufacturer's part numbers with brief description of part name and materials of construction.
  2. Detail assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
  1. Ceiling suspension assembly components.
  2. Method of attaching hangers to building structure.

3. Size and location of initial access modules for suspended ceilings.
  4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- D. Manufacturer Seismic Qualification Certification: Submit certification that enclosures, cabinets, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

#### 1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

#### 1.8 COORDINATION

- A. Coordinate layout and installation of raceways, boxes, fittings, hangers, enclosures, cabinets, and supports with other construction, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists of manufacturers, provide products in conformance with this Section produced by the listed manufacturers.

#### 2.2 RIGID METAL CONDUIT (RMC) and INTERMEDIATE METAL CONDUIT (IMC)

- A. Manufacturers:
  1. Allied Tube and Conduit Div. / A TYCO International Ltd. Company

2. LTV Steel Tubular Products Company
  3. Wheatland Tube Co.
  4. Robroy Industries
  5. Perma-Cote
- B. Rigid Galvanized Steel Conduit (RGS): hot dip galvanized exterior and interior to ANSI C80.1, threads hot dip galvanized after fabrication, for use in accordance with NEC Article "Rigid Metal Conduit: Type RMC", NRTL-listed and labeled under UL 6. Threads shall be hot dip galvanized after fabrication.
- C. Intermediate Metal Conduit (IMC): hot dip galvanized exterior to ANSI C80.6, enamel-coated interior, for use in accordance with NEC Article "Intermediate Metal Conduit: Type IMC", NRTL-listed and labeled under UL 1242
- D. Provide locknuts, bushings, fittings, conduit bodies, junction boxes, pull boxes, and outlet boxes as follows:
1. Locknuts: galvanized steel. Locknuts on outside of NEMA 12 sheet metal enclosures shall be sealing O-ring type.
  2. Bushings: galvanized steel or malleable iron, insulated throat grounding type, with thermoset plastic insulation insert, complete with mechanical ground lug for connection to ground wire.
  3. Fittings: ANSI 80.4, hot-dip galvanized cast steel or malleable iron. PVC-coated conduit fittings shall be PVC-coated to same thickness as the conduit, and shall have sleeves and collars to overlap the joint. Conduit hubs or similar approved fittings shall be provided for conduit entry to water and dust-resistant enclosures.
  4. Expansion and deflection couplings: UL 467 and UL 514B. Suitable for the anticipated amount of movement and direction(s) of movement. Materials of construction: galvanized steel, bronze, stainless steel. Non-metallic components shall be neoprene.
  5. Sealoff fittings: galvanized cast steel or malleable iron, suitable for horizontal or vertical installation. For concealed conduit runs requiring sealoffs, install sealoff fittings in flush-mounted galvanized steel boxes with blank flush covers.
  6. Conduit bodies: galvanized cast steel or malleable iron Form 8 with oil-resistant gasket and galvanized cast steel or malleable iron cover. Provide mogul bodies for fittings in trade sizes 2 inch and larger. When PVC-coated conduit is used, conduit bodies shall be PVC-coated to same thickness, and shall have sleeves to overlap the conduit
  7. Junction boxes: NEMA enclosure type in accordance with Part 3 of this Section
  8. Pull boxes: NEMA enclosure type in accordance with Part 3 of this Section
  9. Outlet boxes: Type FS or FD for exposed locations in non-hazardous areas, NEMA enclosure type in accordance with Part 3 of this Section

## 2.3 ELECTRICAL METALLIC TUBING (EMT)

- A. Manufacturers:
1. Allied Tube and Conduit, a Division of TYCO International.
  2. LTV Steel Tubular Products Company

3. VAW of America, Inc.
  4. Western Tube & Conduit Corp
  5. Wheatland Tube Co.
- B. EMT: galvanized steel interior and exterior to ANSI C80.3, for use in accordance with NEC Article "Electrical Metallic Tubing, Type EMT", NRTL-listed and labeled under UL 797
- C. Provide couplings and connectors, locknuts, bushings, fittings, conduit bodies, junction boxes, pull boxes, and outlet boxes as follows:
1. Zinc coated steel compression type couplings and connectors, ANSI C80.3, UL 514B, suitable for use as grounding fittings. Cast zinc fittings are not acceptable.
  2. Locknuts: galvanized steel
  3. Bushings: galvanized steel or malleable iron, insulated throat grounding type, with thermoset plastic insulation insert, complete with mechanical ground lug for connection to ground wire
  4. Fittings: ANSI 80.4, hot-dip galvanized cast steel or cast aluminum.
  5. Expansion and deflection couplings: UL 467 and UL 514B. Suitable for the anticipated amount of movement and direction(s) of movement. Couplings shall have flexible metal braid for ground continuity, sized for use as NEC equipment grounding conductors.
  6. Conduit bodies: aluminum with oil-resistant gasket and galvanized sheet steel cover.
  7. Junction boxes: NEMA enclosure type in accordance with Part 3 of this Section
  8. Pull boxes: NEMA enclosure type in accordance with Part 3 of this Section
  9. Outlet boxes: galvanized sheet steel for exposed locations in non-hazardous areas, NEMA enclosure type in accordance with Part 3 of this Section

#### 2.4 FLEXIBLE METAL CONDUIT (FMC)

- A. Manufacturers:
1. AFC Cable Systems, Inc.
  2. Alflex Inc.
  3. Anamet Electrical, Inc.; Anaconda Metal Hose.
  4. Electri-Flex Co.
- B. Flexible Metal Conduit (FMC): Galvanized steel, for use in accordance with NEC Article "Flexible Metal Conduit, Type FMC", NRTL-listed and labeled under UL 1
- C. Fittings: screw-in connectors, NEMA FB 1, same material as conduit, and suitable for use as grounding fittings, UL 514B

#### 2.5 Liquidtight FLEXIBLE METAL CONDUIT (LFMC)

- A. Manufacturers:
1. AFC Cable Systems, Inc.
  2. Alflex Inc.
  3. Anamet Electrical, Inc.; Anaconda Metal Hose.

4. Electri-Flex Co.

- B. Liquidtight flexible metal conduit (LFMC): Flexible steel type UA conduit with PVC jacket, for use in accordance with NEC Article "Liquidtight Flexible Metal Conduit: Type LFMC", NRTL-listed and labeled under UL 360. Non-UL listed LFMC is not acceptable.
- C. Fittings: Insulated-throat screw-in connectors, NEMA FB 1, UL 514B, galvanized malleable iron or steel. Connectors shall be suitable for use as grounding fittings. Provide fittings with bonding jumper connections for exterior bonding jumpers at motors.

2.6 BOXES

- A. Manufacturers:
  - 1. Bell
  - 2. Emerson/General Signal; Appleton Electric Company.
  - 3. RACO; Division of Hubbell, Inc.
  - 4. Spring City Electrical Manufacturing Co.
  - 5. Thomas & Betts Corporation.
- B. Sheet Metal Outlet and Device Boxes: Stamped galvanized steel, NEMA OS 1, UL 50, UL 514A.
- C. Cast Metal Outlet and Device Boxes: galvanized and epoxy- or polyester-coated malleable iron NEMA FB 1, Type FD, with gasketed cover, UL 50, UL 514A.
- D. Small Sheet Metal Pull and Junction Boxes: zinc coated steel, NEMA OS 1, UL 50, UL 514A.
- E. Sheet Metal Pull and Junction Boxes: NEMA 250, Type 1 galvanized or painted steel, with continuous hinged cover and flush latch.
- F. Surface-Mounted Enclosures for terminal blocks and electrical equipment and components: NEMA 250, Type 1 painted steel, with continuous hinged cover and flush latch.
- G. Freestanding Enclosures for electrical equipment and components: NEMA 250, Type 1 painted steel, electrical enclosure with hinged door and removable sheet steel interior panel painted white. Painted cabinets shall be finished inside with white paint. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

2.7 single conduit hangers

- A. Manufacturers:
  - 1. Appleton
  - 2. Crouse-Hinds
  - 3. Erico International Corporation (Caddy)
  - 4. Thomas and Betts (Kindorf, Steel City)

5. Unistrut

- B. Single RMC and IMC attachment to structural steel: galvanized malleable iron PC (parallel clamp), EC (edge clamp), and RC (right angle clamp) type conduit-to-structural-steel clamps, or galvanized steel clevis hangers on galvanized steel threaded rods attached to galvanized malleable iron beam clamps. Bolts shall be galvanized steel.
- C. Single RMC and IMC attachment to concrete and masonry surfaces: galvanized malleable iron one-hole clamp and galvanized malleable iron clamp-back, or galvanized steel clevis hangers on galvanized steel threaded rods attached to galvanized steel rod hanger fitting bolted to concrete with expansion bolts. Bolts shall be galvanized steel.
- D. Single EMT attachment to structural steel: galvanized malleable iron beam clamp with hardened set screw and threaded hole for galvanized steel single-bolt conduit hanger or threaded rod and clevis hanger. Bolts shall be plated steel.
- E. Single EMT attachment to concrete and masonry surfaces: galvanized steel one-hole clamp and galvanized steel clamp-back, or plated steel single-bolt hangers on plated steel threaded rods attached to galvanized steel rod hanger fitting bolted to concrete with expansion bolts. Single piece combination one-hole clamp and clamp-back hangers are also acceptable. Bolts shall be plated steel.

2.8 multiple conduit hangers (CHANNEL SUPPORTS)

- A. Manufacturers:
  - 1. Thomas & Betts (Kindorf)
  - 2. Unistrut
  - 3. Cooper B-Line
  - 4. GS Metals Inc.
- B. Steel channel and associated hardware and fittings:
  - 1. 1-1/2 x 1-1/2 inch nominal size, minimum. UL 5B listed and labeled. Thickness as required for the application, minimum 0.071 inches.
  - 2. Deflection of individual support channels shall not exceed 1/128<sup>th</sup> of span when loaded with conduit plus 200 pounds.
  - 3. Electrogalvanized: Electrolytically zinc coated conforming to ASTM B633 Type III SC1.
  - 4. Pregalvanized: Zinc coated by hot-dip process prior to roll forming. Zinc weight shall be G90 conforming to ASTM A 653.
  - 5. Hot-dip galvanized after fabrication: Zinc-coated after all manufacturing and forming operations are completed. Zinc coating conforming to ASTM A 123 or A 153.
  - 6. Clean dry indoor areas unless otherwise noted: painted
  - 7. Mechanical rooms: electro-galvanized.
  - 8. Bolts: Grade 3 or better. Finish and materials to match channel, except that electroplated bolts shall be used with painted and electroplated steel channel, and stainless steel bolts shall be used with epoxy coated channel.

## 2.9 CONDUIT SLEEVES AND SEALING FITTINGS

- A. Manufacturers:
  - 1. Appleton
  - 2. Crouse-Hinds
  - 3. Spring City Electric
  - 4. Thomas & Betts
  - 5. O.Z. Gedney
  
- B. Wall and Floor Sleeves:
  - 1. Hot-dip galvanized steel pre-fabricated conduit sleeves with welded water-stop ring.
  - 2. Galvanized steel, PVC, and polyethylene sleeves that are part of a manufacturer's standard wall seal assembly are also acceptable, subject to compliance with the fire resistant rating of the related walls and floors.
  
- C. Conduit-to-Sleeve Sealing Fittings:
  - 1. Synthetic elastomeric gland with galvanized steel compression plates sized for the conduit OD and sleeve ID, or a manufactured assembly of hot-dip galvanized pressure plates, neoprene sealing grommets, and cast or malleable iron sealing bodies with zinc-rich epoxy coating, with factory-assembled galvanized steel, PVC, or polyethylene pipe sleeve. Segmented seals are also acceptable for conduits 4-inch trade size and larger.
  - 2. Sealing fittings for wall penetrations with water or soil on one side shall have seals installed at both ends of the conduit sleeve or core-drilled hole.
  - 3. Where single conductors pass through a single sleeve, select materials to mitigate the effects of inductive heating.
  - 4. Provide ground wire attachment bolts for manufactured sleeve assemblies.
  - 5. Seals shall have fire ratings equal to the fire-resistant rating of the wall.

## 2.10 CONDUIT INTERIOR SEALING FITTINGS

- A. Manufacturers:
  - 1. Crouse-Hinds
  - 2. O.Z. Gedney
  - 3. Thomas & Betts
  
- B. Conduit-to-Cable Sealing Fittings:
  - 1. For exposed conduit ends without pull and junction boxes: Conduit fitting with synthetic elastomeric sealing gland with galvanized steel compression plates drilled for the conduit ID and cable(s) OD, retained by threaded collar at the end of the conduit.
  - 2. For exposed conduit ends entering pull or junction box: Conduit fitting suitable for installation of locknuts at conduit entry to sheet metal box, and bushing with synthetic elastomeric sealing gland with galvanized steel compression plates drilled for the conduit ID and cable(s) OD, retained by threaded collar at the end of the conduit.
  - 3. Seal shall be watertight at 50 feet of water pressure.

4. Where single conductors pass through a seal, select materials to mitigate the effects of inductive heating.
5. Where bare stranded copper conductors pass through sealing fittings, place an exothermic weld in the stranded cable to prevent water from leaking through the strands.

#### 2.11 conduit expansion and deflection fittings

- A. Manufacturers:
  1. Crouse-Hinds
  2. Spring City Electric
  3. O.Z. Gedney
  4. Thomas & Betts
- B. Conduit expansion and deflection fittings:
  1. Suitable for the anticipated expansion joint elongation and deflection at each expansion joint.
  2. Materials of construction: Hot dip galvanized ductile iron body, neoprene sealing sleeve, stainless steel clamps, tinned flexible copper equipment bonding jumper.

#### 2.12 FACTORY FINISHES

- A. Finish: For painted steel enclosures, provide manufacturer's standard commercial and industrial coating in ANSI 61 light grey color, or different color when required by the NEC.
- B. Field painting will be required for uncoated cast iron, steel, galvanized, zinc-coated, and factory primed surfaces. Products shall be degreased and made suitable for field painting prior to packaging for shipment.

### **PART 3 - EXECUTION**

#### 3.1 DELIVERY, STORAGE, AND HANDLING

- A. Deliver raceways, boxes, and fittings to jobsite in factory packaging.
- B. Store in clean, dry, weatherproof locations.
- C. Handle in accordance with manufacturer's recommendations.

#### 3.2 RACEWAY APPLICATIONS

- A. Outdoor raceways, boxes, and fittings:

1. Exposed: rigid galvanized steel conduit.
2. Concealed in hollow masonry exterior walls: EMT conduit.
3. Conduits containing branch circuit wiring from VFCs to motors: Rigid galvanized steel.
4. Connections to transformers, motor-driven equipment, vibrating equipment, and equipment requiring position adjustment, e.g., rail-mounted motors: liquidtight flexible metal conduit.
5. Boxes and fittings: as described in each raceway sub-section, and recommended as suitable for the particular application by the manufacturer.
6. Enclosures: refer to Division 16 Section "Electrical General Provisions"

B. Indoor raceways, boxes, and fittings:

1. Exposed: rigid galvanized steel conduit or electrical metallic tubing.
2. Concealed: electrical metallic tubing flexible metal conduit.
3. Connections to transformers, motor-driven equipment, vibrating equipment, and equipment requiring position adjustment, e.g., rail-mounted motors: liquidtight flexible metal conduit.
4. Lighting fixture whips: flexible galvanized steel conduit.
5. Damp or Wet Locations: rigid galvanized steel conduit
6. Boxes and fittings: as described in each raceway sub-section, and recommended as suitable for the particular application by the manufacturer.
7. Enclosures: NEMA 250, Type 1, unless otherwise specified in Division 16 Section "Electrical General Provisions".

C. Minimum Raceway Size: 3/4-inch trade size, except that 1/2-inch trade size may be used for lighting circuits above suspended ceilings.

### 3.3 INSTALLATION – GENERAL

- A. Install raceways, boxes, and fittings in accordance with manufacturer's installation instructions and NEC requirements as a minimum, and comply with the additional requirements described in this Section.
- B. Conduits shall be electrically and mechanically continuous, and suitable for use as an equipment grounding conductor. Make up threaded joints wrench tight.
- C. When coordination drawing submittals are specified in Part 1 of this Section, do not commence work until coordination drawings for the entire building are approved.
- D. Install and route emergency system raceways independently of other raceways systems, except where specific exceptions are permitted by the NEC.
- E. Fasten boxes in wet and damp areas using external mounting feet. Do not drill through boxes.
- F. Comply with NEC requirements for sizing outlet and junction boxes to accommodate wires, splices, and devices.

- G. Bends and offsets between pull points shall not exceed a cumulative total of 270 degrees unless otherwise approved by the Engineer. Maximum distance between pull points in conduit systems inside buildings shall be 100 feet unless otherwise approved by the Engineer.
- H. Raceways shall be routed in accordance with the following guidelines:
  - 1. Run conduits exposed, concealed, and underground as indicated on the Drawings.
  - 2. The preferred location for horizontal conduit runs is just below the ceiling structural supports.
  - 3. Do not obstruct access to equipment for operation and maintenance. Coordinate conduit runs with the work of other trades. Plan conduit runs to avoid lighting fixtures, and leave space for easy access to HVAC equipment, motors, and duct access hatches and doors.
  - 4. Route conduits around doors, windows, hatches, louvers, and other building openings, and around range and fume hoods.
  - 5. Group conduits on horizontal trapeze hangers or on wall-mounted steel channel where long horizontal runs are required.
  - 6. Do not run conduits through stairwells unless required for connection to equipment located in the stairwell.
  - 7. Maintain eight feet minimum clearance above finished floor wherever it is physically possible to do so. Comply with OSHA requirements for minimum headroom.
  - 8. Comply with raceway, boxes, and fittings details shown on the Drawings.
  - 9. Where conduits enter the top of electrical equipment enclosures and control panels, install conduit interior sealing fittings to prevent entry of water and condensation from conduit.
- I. Cut conduits square with roller-wheel pipe cutter. Hacksaw cuts are acceptable only if the entire conduit is swabbed clean after cutting and threading is completed. Conduits cut in the field shall be threaded with sharp, standard NPT dies to achieve a fully cut tapered thread with a minimum of five full tapered threads at the end of the conduit. Running threads are not acceptable. Over- and under-threading are not acceptable. After threading, ream conduit ends, remove cuttings and debris from inside and outside of conduit, degrease, and apply cold spray-on zinc-rich paint.
- J. Conduit bends shall be made with conduit bending tools manufactured for the purpose. Comply with conduit and bending tool manufacturers' instructions. Use specially sized shoes in bending tools for PVC-coated rigid galvanized steel conduits.
- K. Do not cut or drill holes in structural beams and columns, or other structural members. Do not weld raceway supports to structural steel.
- L. Join raceways with fittings designed and approved for that purpose and make joints wrench tight. Comply with NEC requirements for minimum thread engagement in Hazardous Classified areas.

- M. Provide expansion, deflection, or expansion & deflection couplings at building expansion joints. Expansion and deflection fittings shall comply with UL 467 and UL 514B, and shall be suitable for the anticipated amount of movement and direction(s) of movement.
- N. Complete raceway installation before starting conductor installation.
- O. Support raceways as specified in Division 16 Section "Basic Electrical Materials and Methods."
- P. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping".
- Q. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- R. Terminations:
  - 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box. Install bushings wrench-tight.
  - 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
  - 3. Install temporary closures to prevent foreign matter from entering raceways.
- S. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- T. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  - 2. At hazardous classified locations and where otherwise required by the NEC.
- U. Flexible Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate equipment bonding jumper across flexible connections.
- V. Telephone and Signal System Raceways, 2-Inch Trade Size and Smaller: In addition to above requirements, install raceways in maximum lengths of 150 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.

### 3.4 INSTALLATION – EXPOSED RACEWAYS, BOXES AND FITTINGS

- A. Install raceways, boxes, and fittings exposed as indicated on the Drawings.
- B. Install exposed raceways parallel or at right angles to nearby surfaces or structural members.
  - 1. Run raceways together in groups on common supports wherever possible.
  - 2. Do not use mechanical piping or ceiling supports to support conduit runs.
- C. Make concentric bends in parallel exposed conduit runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- D. Surface-mounted channel supports shall be 1-1/2 inch x 1-1/2 inch channel bolted to wall or ceiling with expansion anchors.
- E. Suspended (trapeze) channel supports shall be 1-1/2 inch x 1-1/2 inch channel suspended from minimum 3/8 inch threaded rod. Fasten rods to structural steel with beam clamps or channel assemblies designed specifically for each application. Fasten threaded rods to concrete with expansion bolts and threaded rod hanger, or concrete channel inserts
- F. Keep raceways at least 6 inches away from parallel runs of flues and mechanical piping (including insulation). Install horizontal raceway runs above water and steam piping.
- G. Install electrical enclosures and cabinets plumb. Support at each corner.

### 3.5 INSTALLATION – CONCEALED RACEWAYS, BOXES AND FITTINGS

- A. Install raceways, boxes, and fittings concealed, including above suspended ceilings, in partitions, and within or below floor slabs, as indicated on the Drawings.
- B. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.

### 3.6 PROTECTION DURING CONSTRUCTION

- A. Provide final protection and maintain conditions that ensure coatings and finishes without damage or deterioration at time of Substantial Completion.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

### 3.7 CLEANING & PAINTING

- A. Swab conduits clean after installation and plug ends until conductors are installed.

- B. Remove dust, construction debris, plaster and paint spatters from raceways, boxes, and fittings after all trades have completed their work, and prior to painting.
- C. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes, touch up damage, and prepare for finish painting in accordance with Division 9 Section "Painting and Finishing".

### 3.8 IDENTIFICATION

- A. Identify raceways, boxes, and fittings as described in Division 16 Section "Electrical General Provisions".

END OF SECTION

## **SECTION 262726**

### **WIRING DEVICES**

#### **PART 1 - GENERAL**

##### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

##### 1.2 SUMMARY

- A. This Section includes the following:
  - 1. Single and duplex receptacles, ground-fault circuit interrupters, integral surge suppression units, and isolated-ground receptacles.
  - 2. Single- and double-pole snap switches and dimmer switches.
  - 3. Device wall plates.

##### 1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. PVC: Polyvinyl chloride.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.
- F. UTP: Unshielded twisted pair.

##### 1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.

- D. Field quality-control test reports.

#### 1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

#### 1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
  - 1. Cord and Plug Sets: Match equipment requirements.

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Wiring Devices:
    - a. Arrow Hart /Cooper - Crouse-Hinds Subsidiary
    - b. Bryant Electric, Inc./Hubbell Subsidiary.
    - c. Hubbell Incorporated; Wiring Device-Kellems.
    - d. Leviton Mfg. Company Inc.
    - e. Pass & Seymour/Legrand; Wiring Devices Div.
  - 2. Multi-outlet Assemblies:
    - a. Hubbell Incorporated; Wiring Device-Kellems.
    - b. Wiremold Company (The).

#### 2.2 RECEPTACLES

- A. Straight-Blade-Type Receptacles: Heavy duty, wide body design, one piece triple wipe brass power contacts, grounding type, one piece mounting strap without the use of rivets and with integral ground contacts, back and side wired, enclosed in composition, or nylon case, impact resistant nylon face. Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G, and UL 498.
- B. Rating: 20Amp, 125 Volt, NEMA 5-20R.

- C. Straight-Blade and Locking Receptacles: Heavy-Duty grade.
- D. GFCI Receptacles: Straight blade, non-feed-through type, Hospital grade, with integral NEMA WD 6, duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4-inch- deep outlet box without an adapter.

## 2.3 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
  - 1. Plate-Securing Screws: Metal with head color to match plate finish.
  - 2. Material for Finished Spaces: 0.035-inch- thick, satin-finished stainless steel.
  - 3. Material for Unfinished Spaces: Galvanized steel.
  - 4. Material for Wet Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in "wet locations."

## 2.4 FINISHES

- A. Color:
  - 1. Wiring Devices Connected to Normal Power System: Brown, unless otherwise indicated or required by NFPA 70.
  - 2. Wiring Devices Connected to Emergency Power System: Red.
  - 3. Isolated-Ground Receptacles: Orange.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install devices and assemblies level, plumb, and square with building lines.
- B. Install wall dimmers to achieve indicated rating after derating for ganging according to manufacturer's written instructions.
- C. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' written instructions.
- D. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- E. Remove wall plates and protect devices and assemblies during painting.

### 3.2 IDENTIFICATION

- A. Comply with Division 16 Section "Basic Electrical Materials and Methods."
  - 1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

### 3.3 CONNECTIONS

- A. Ground equipment according to Division 16 Section "Grounding and Bonding."
- B. Connect wiring according to Division 16 Section "Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
  - 2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- B. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION

## SECTION 262816

### ENCLOSED SWITCHES AND CIRCUIT BREAKERS

#### PART 1 - GENERAL

##### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

##### 1.2 SUMMARY

- A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
  - 1. Fusible switches.
  - 2. Nonfusible switches.
  - 3. Molded-case circuit switches.
  - 4. Molded-case switches.
  - 5. Enclosures.

##### 1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. HD: Heavy duty.
- C. RMS: Root mean square.
- D. SPDT: Single pole, double throw.

##### 1.4 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.
  - 2. Current and voltage ratings.
  - 3. Short-circuit current rating.
  - 4. UL listing for series rating of installed devices.

5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Qualification Data: For testing agency.
- D. Field quality-control test reports including the following:
  1. Test procedures used.
  2. Test results that comply with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- E. Manufacturer's field service report.
- F. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
  1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
  2. Time-current curves, including selectable ranges for each type of circuit breaker.

#### 1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
  1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

## 1.6 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
  - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
  - 2. Altitude: Not exceeding 6600 feet.

## 1.7 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

## 1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Spare Indicating Lights: Six of each type installed.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
    - a. Cutler Hammer.
    - b. Square D.
    - c. Siemens Energy & Automation, Inc.

### 2.2 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers:
  - 1. Eaton Corporation; Cutler-Hammer Products.
  - 2. Siemens Energy & Automation, Inc.
  - 3. Square D/Group Schneider.

- B. General: Comply with federal specification WS-865C and NEMA KS1-M83.
- C. Fusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- D. Nonfusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- E. Switch Operation:
  - 1. Horsepower rated, with a quick make, quick break operating mechanism, with number of poles, fuses, NEMA type, and capacities indicated.
  - 2. Voltage Rating: 600 volts for 480 volt systems, 240 volts for 240 or 208 volt systems.
- F. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
  - 3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

## 2.3 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

- A. Manufacturers:
  - 1. Eaton Corporation; Cutler-Hammer Products.
  - 2. Siemens Energy & Automation, Inc.
  - 3. Square D/Group Schneider.
- B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  - 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
- C. Molded-Case Circuit-Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
  2. Lugs: Mechanical style suitable for number, size, trip ratings, and conductor material.
  3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
  4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- D. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- E. Molded-Case Switch Accessories:
1. Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.
  2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.

## 2.4 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
1. Outdoor Locations: NEMA 250, Type 4X.
  2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4X.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 CONCRETE BASES

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

### 3.3 INSTALLATION

- A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- C. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

### 3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 16075, "Electrical Identification."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Section 16075, "Electrical Identification."

### 3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.
- B. Prepare for acceptance testing as follows:
  - 1. Inspect mechanical and electrical connections.
  - 2. Verify switch and relay type and labeling verification.
  - 3. Verify rating of installed fuses.
  - 4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:
  - 1. Test mounting and anchorage devices according to requirements in Division 16 Section "Seismic Controls for Electrical Work."

2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Infrared Scanning:
  - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
  - b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
  - c. Instruments, Equipment and Reports:
    - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - 2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

### 3.7 CLEANING

- A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.
- B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 262816